Land Surface Temperature Records – are we keeping our side of the bargain?

Peter Thorne, CICS-NC, NCSU and NOAA's NCDC, Asheville, NC, USA

With thanks to and on behalf of the International Surface Temperature Initiative steering committee.

www.surfacetemperatures.org

Talk outline

- Surface Temperature Initiative 101
- Backstory
- Exeter workshop outcomes and progress in key areas
  - Databank
  - Dataset creation
  - Benchmarking of performance (expanded upon in next talk)
  - Data and product serving
- Remaining challenges
- Personal thoughts on how to ensure SST and LST can be used seamlessly

Surface Temperature Initiative 101

- In some aspects this is us terrestrial folks playing catch up.
- Only, strictly speaking, two independent and truly global land surface temperature products
- Data availability is limited and fragmented. Proprietary issues.
- Metadata – poor is charitable
- Few user tools
- Worse degree of coordination (no MARCDAT and other marine community equivalents)

The big question

- Can we create a process that creates a suite of verified estimates of land surface temperatures that can be used to answer scientific and societal demands of the 21st Century?
  - Open and transparent
  - Better understanding of fundamental instrument performance
  - Consistent performance evaluation
  - User tools
  - Not just monthly at the largest scales. Daily, sub-daily, regional and local

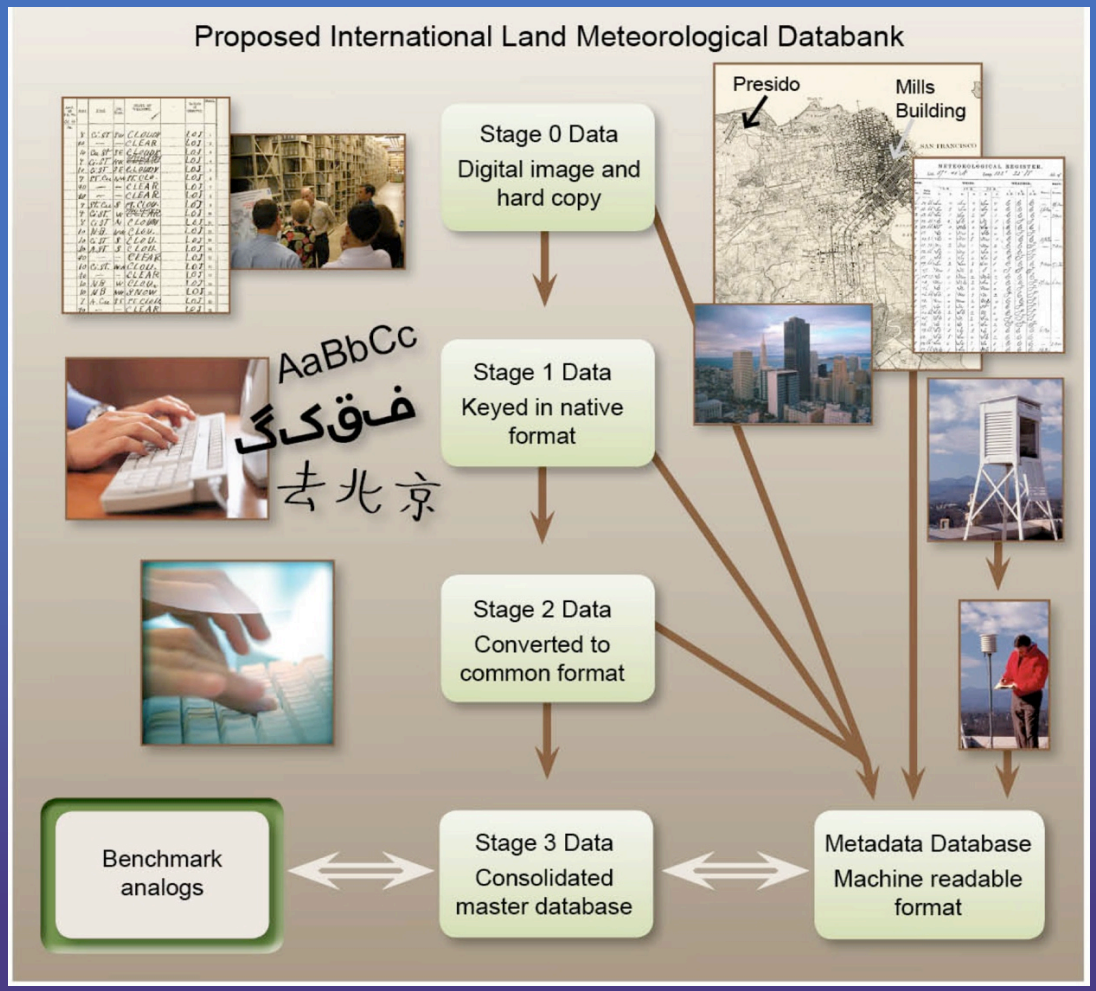
Backstory

- Discussions within Hadley Centre for several years recognizing the disparity between ongoing marine efforts and relative stagnation of land efforts.
  - Pushback
- Climategate came along …
  - Sharpens minds, opens doors that were closed
  - Stress that fundamentally the initiative is NOT a response to this.
- UK submission to WMO CCl
- Exeter workshop to instigate process

Exeter workshop

- 80 experts including climate scientists, metrologists, statisticians, software engineers.
- International
- Strong marine community involvement recognizing the large amount we can learn from marine efforts and importance of coordination.
- White papers solicited in advance and open for comment on a moderated blog

Agreed outcomes and progress



Databank progress

- Largely looking to build on the ICOADS experience (and with ICOADS expert advice)
- Task teams set up
  - Provenance and version control
  - Data rescue
- Initial database starting to come together
  - Hosted at www.gosic.org
  - First version planned for April 2012

Databank challenges

- Numerous digital, image and hardcopy sources
  - Several sources for same station
    - Not always in agreement
  - Different formats
  - Different languages
  - No comprehensive knowledge of what data exists
  - Very poor metadata
- Pull through and collation
- Proprietary issues

Stage 0 - Data in hard / image copy

- 2000+ boxes of data in the NCDC library
- Holdings in other libraries and repositories, particularly former colonial powers
- Holdings literally rotting away or seen as a nuisance in many countries
- Holdings of data not taken by NMSs

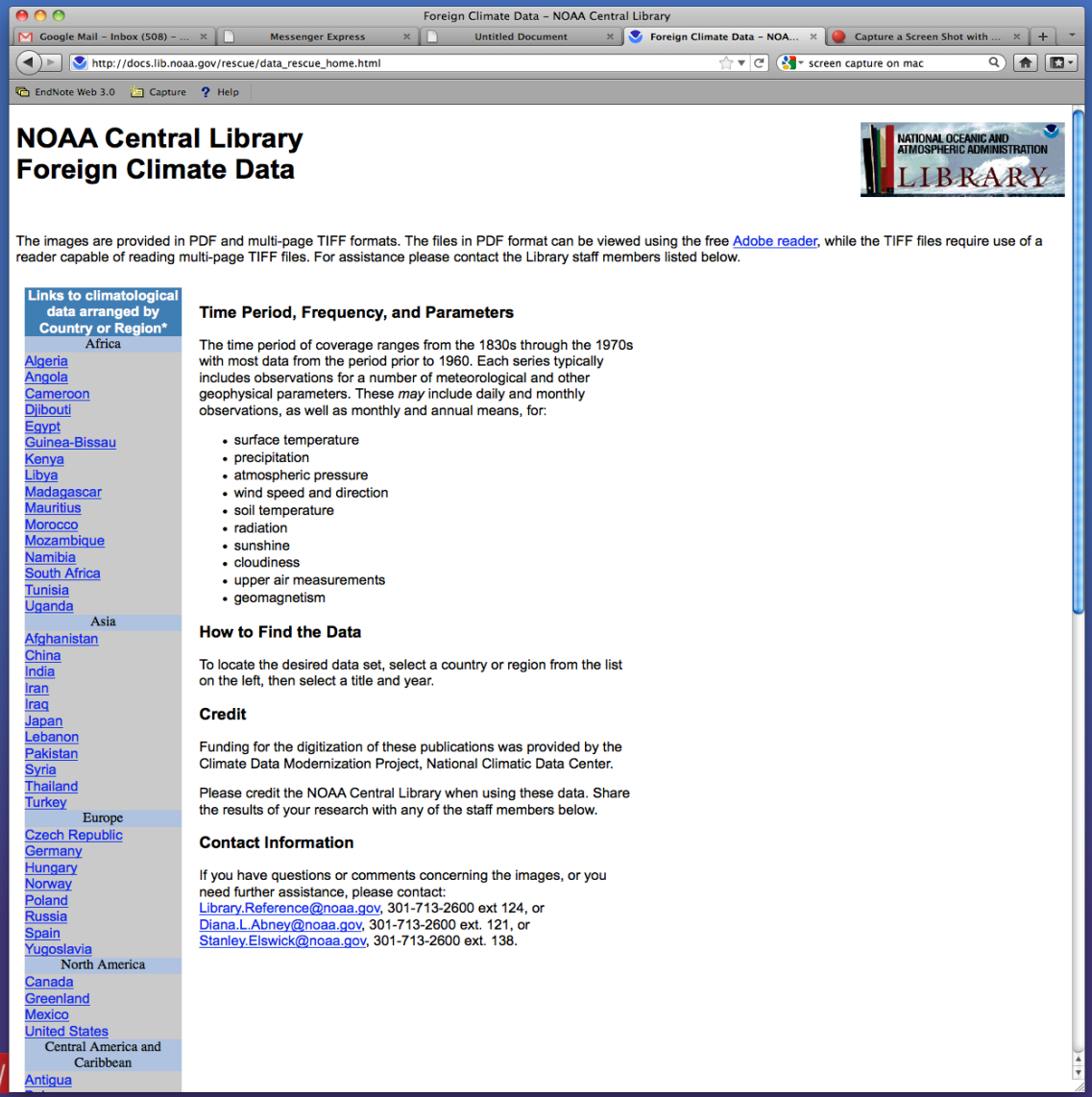
www.iedro.org

cics.nc

The UNIVERSITY of NORTH CAROLINA
A Multi-Campus University

NC State University

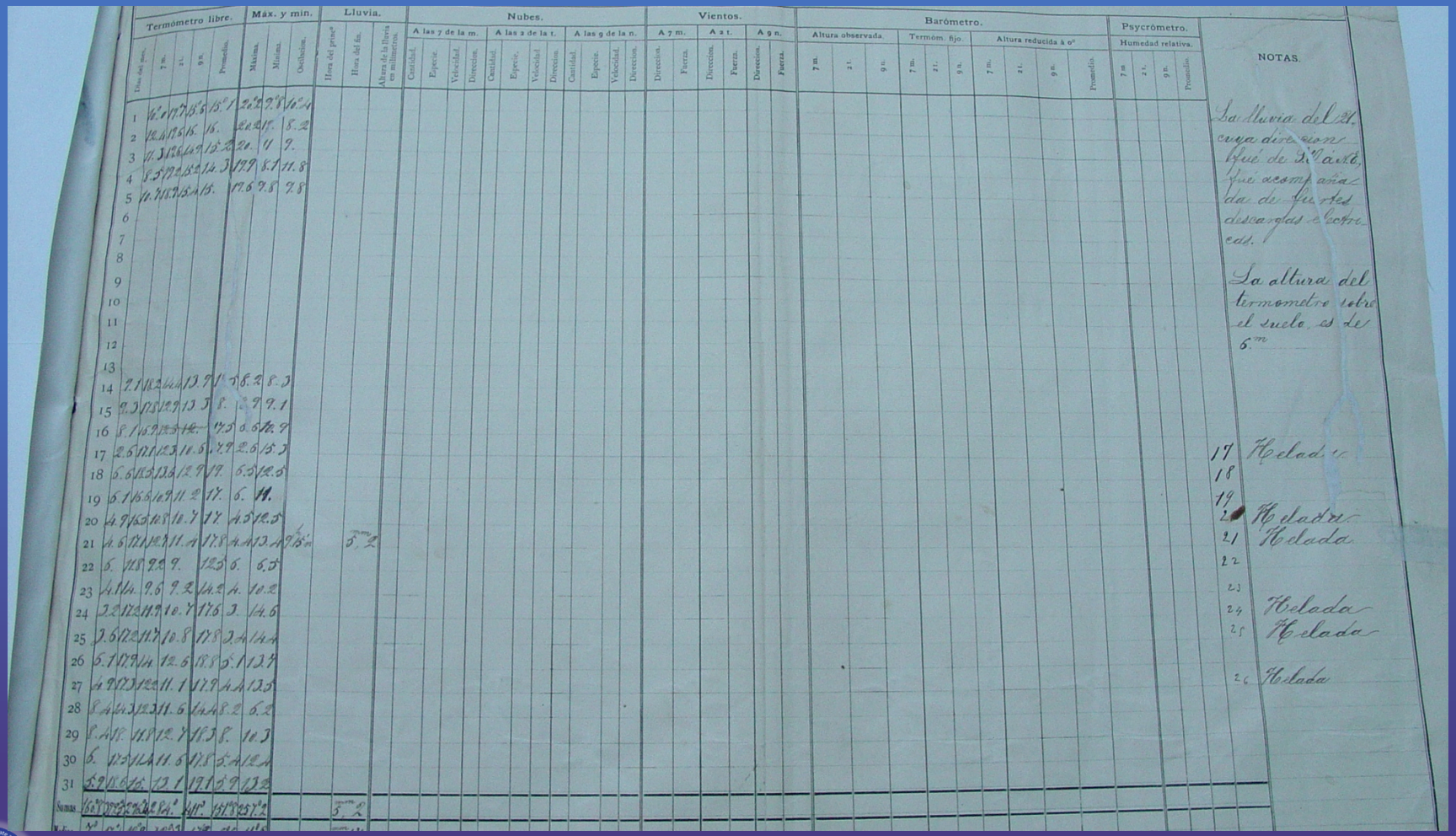
Imaged data

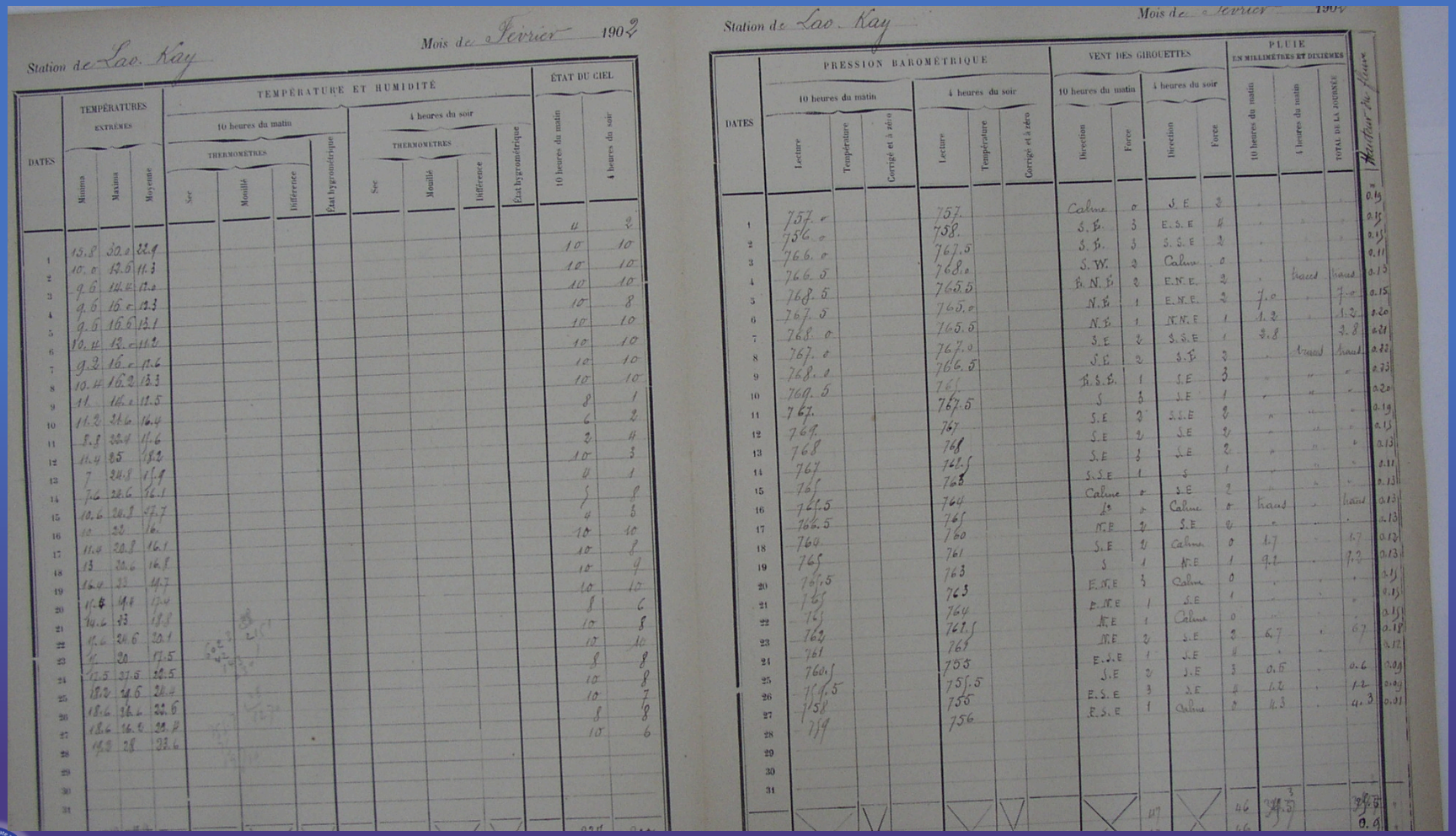


cics.nc

The UNIVERSITY of NORTH CAROLINA
A Multi-Campus University

NC State University


Termómetro libre.
Máx. y min.
Lluvia.
Nubes.
Vientos.
Barómetro.
Psycrómetro.
NOTAS.
La lluvia del 21. cuya dirección fué de S.W. á N.E. fué acompañada de fuertes descargas eléctricas.
La altura del termometro sobre el suelo es de 6.m
17 Helada
18
19
20 Helada
21 Helada
22
23
24 Helada
25 Helada
26 Helada



Station de Lao. Kay — Mois de Février 1902

DATES	TEMPÉRATURES EXTRÊMES Minima	Maxima	Moyenne	TEMPÉRATURE ET HUMIDITÉ 10 heures du matin THERMOMÈTRES Sec	Mouillé	Différence	État hygrométrique	4 heures du soir THERMOMÈTRES Sec	Mouillé	Différence	État hygrométrique	ÉTAT DU CIEL 10 heures du matin	4 heures du soir
1	13.8	30.2	22.0									4	2
2	10. 0	13.6	11.3									10	10
3	9.6	14.4	12.0									10	10
4	9.6	16. 0	12.3									10	8
5	9.6	16.6	13.1									10	10
6	10. 4	13. 0	11.2									10	10
7	9.2	16. 0	12.6									10	10
8	10. 4	16.2	13.3									10	10
9	11	16. 0	13.5									8	1
10	11.2	24.6	16.4									6	2
11	8.8	30.4	17.6									2	4
12	11.4	25	18.2									10	3
13	7	24.8	15.9									4	1
14	7.6	28.6	16.1									5	8
15	10.6	28.8	17.7									4	3
16	10	22	16.									10	10
17	11.4	28.8	16.1									10	8
18	13	30.6	16.8									10	4
19	10.4	22	14.7									10	10
20	11.8	19.4	13.4									8	6
21	14.6	23	18.8									10	8
22	11.6	24.6	20.1									10	10
23	9	20	17.5									8	8
24	12.5	27.5	22.5									10	8
25	13.2	24.6	20.4									10	7
26	18.6	24.4	22.6									8	8
27	18.6	26.2	22.2									10	6
28	19.2	28	23.6										
29													
30													
31													

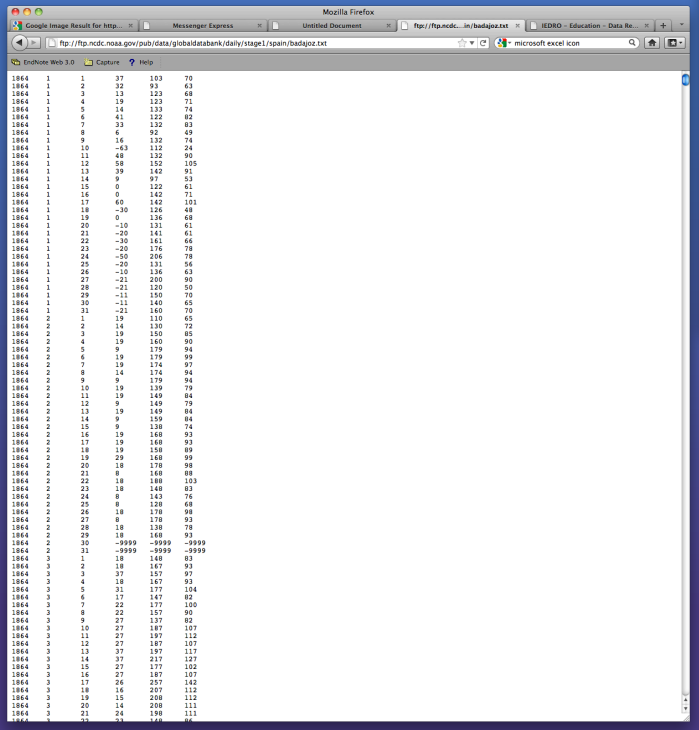
Station de Lao. Kay — Mois de Février 1902

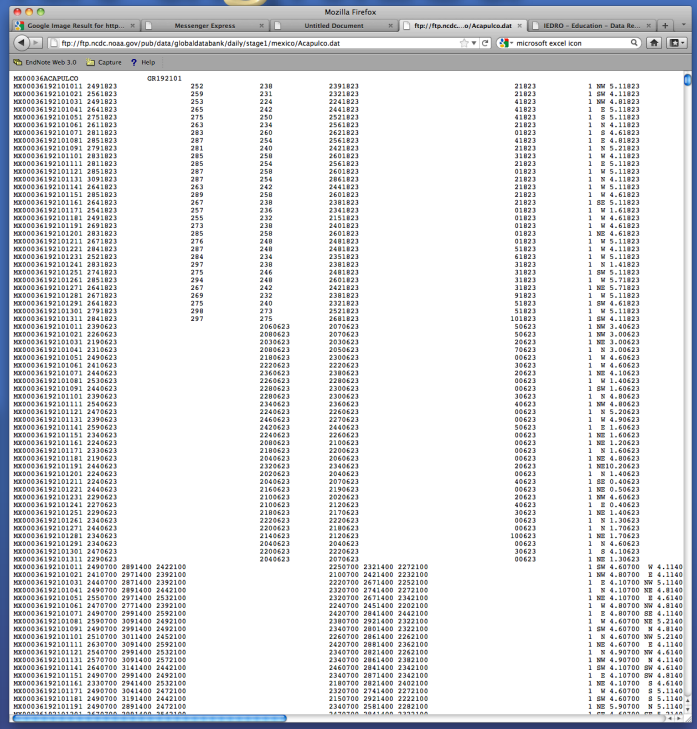
DATES	PRESSION BAROMÉTRIQUE 10 heures du matin Lecture	Température	Corrigé et à zéro	4 heures du soir Lecture	Température	Corrigé et à zéro	VENT DES GIROUETTES 10 heures du matin Direction	Force	4 heures du soir Direction	Force	PLUIE EN MILLIMÈTRES ET DIXIÈMES 10 heures du matin	4 heures du matin	TOTAL DE LA JOURNÉE	Hauteur des fleuves
1	757.			757.			Calme	0	S. E	2				0.19
2	756.			758.			S. E.	3	E. S. E	4				0.15
3	766.			767.5			S. E.	3	S. S. E	2				0.11
4	766. 5			768.			S. W.	2	Calme	0				0.13
5	768. 5			765.5			E. N. E.	2	E. N. E.	2		traces	traces	0.15
6	767. 5			765.			N. E.	1	E. N. E.	2	7.0		7.0	0.20
7	768. 0			765.5			N. E.	1	N. N. E	1	1.2		1.2	0.21
8	767.			767.			S. E	2	S. S. E	1	2.8		2.8	0.22
9	768.			766.5			S. E	2	S. E	2		traces	traces	0.23
10	769. 5			767			E. S. E.	1	S. E	3				0.20
11	767.			767.5			S	3	S. E	1				0.19
12	769.			767			S. E	2	S. S. E	2				0.15
13	768			768			S. E	2	S. E	2				0.13
14	767			768.5			S. E	3	S. E	2				0.11
15	765			768			S. S. E	1	S	1				0.13
16	765.5			764			Calme	0	S. E	2				0.13
17	766.5			765			N. E	2	Calme	0	traces		traces	0.13
18	760.			760			S. E	2	S. E	2				0.13
19	765			761			S	1	Calme	0	1.7		1.7	0.13
20	765.5			763			E. N. E	3	N. E	1	9.2		9.2	0.13
21	765			763			E. N. E	1	Calme	0				0.15
22	765			764			N. E	1	S. E	1				0.15
23	762			762.5			N. E	2	S. E	2	6.7		6.7	0.18
24	761			765			E. S. E	1	S. E	1				0.12
25	760.5			765			S. E	2	S. E	3	0.6		0.6	0.09
26	759.5			755.5			E. S. E	3	S. E	4	1.2		1.2	0.09
27	758			755			E. S. E	1	Calme	0	4.3		4.3	0.01
28	759			756										
29														
30														
31														
								47			46	39.3	39.3	
													0.9	

Data currently digitized

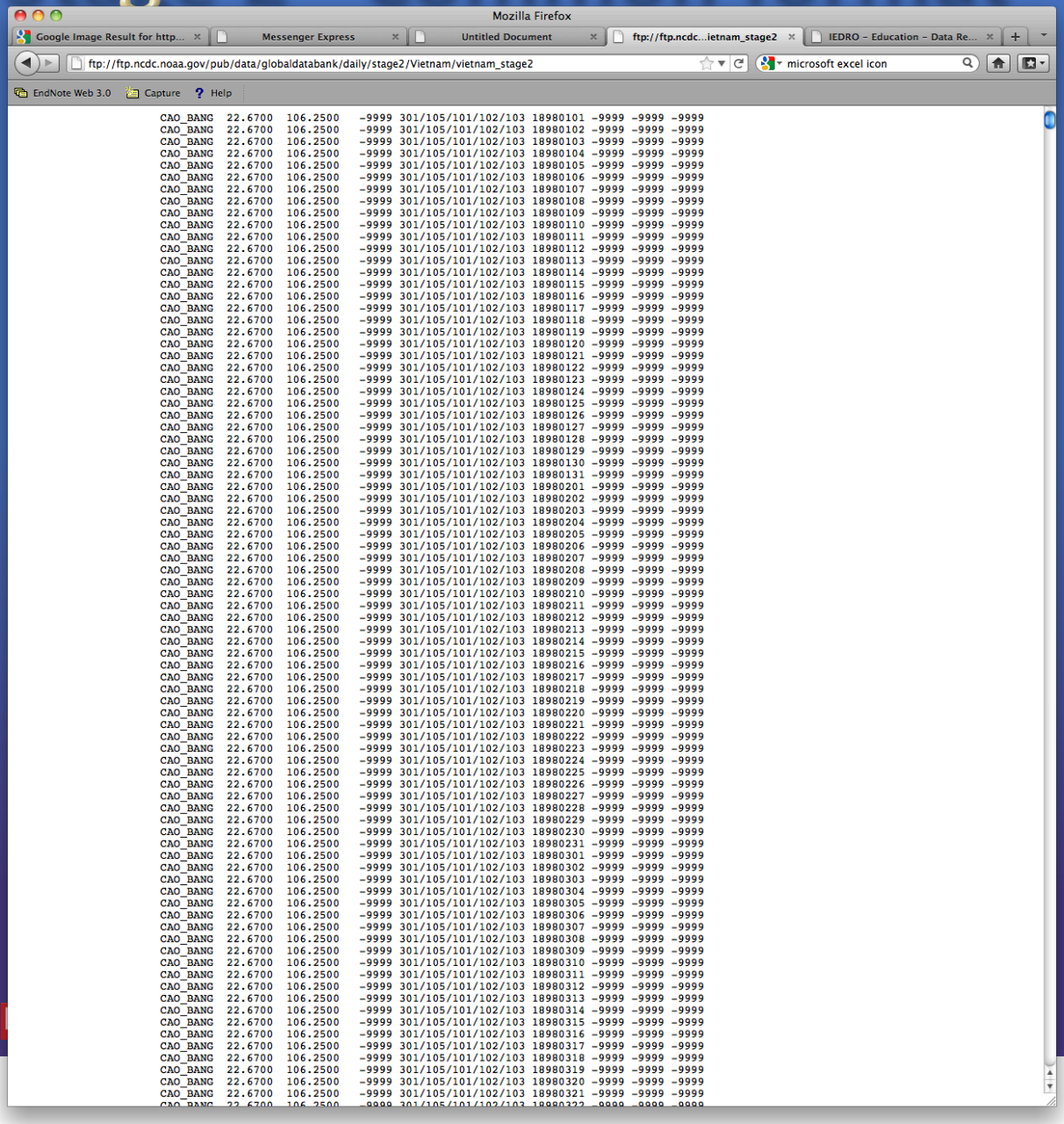
- Numerous public holdings
  - NCDC
  - UCAR
  - RIHMI
  - Regional and national holdings
- Some restricted for commercial reasons

Stage 1 - Native format digitized





Stage 2 - Common format




```
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980101 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980102 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980103 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980104 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980105 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980106 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980107 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980108 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980109 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980110 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980111 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980112 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980113 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980114 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980115 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980116 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980117 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980118 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980119 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980120 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980121 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980122 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980123 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980124 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980125 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980126 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980127 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980128 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980129 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980130 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980131 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980201 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980202 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980203 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980204 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980205 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980206 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980207 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980208 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980209 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980210 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980211 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980212 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980213 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980214 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980215 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980216 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980217 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980218 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980219 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980220 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980221 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980222 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980223 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980224 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980225 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980226 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980227 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980228 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980229 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980230 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980231 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980301 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980302 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980303 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980304 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980305 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980306 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980307 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980308 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980309 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980310 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980311 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980312 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980313 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980314 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980315 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980316 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980317 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980318 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980319 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980320 -9999 -9999 -9999
CAO_BANG  22.6700  106.2500   -9999 301/105/101/102/103 18980321 -9999 -9999 -9999
```

Getting data provider buy in

- Hearts and minds
  - Scientific value
  - WMO support?
  - Greater intrinsic value to data that is open
- Return value added products
  - Normals and extended normals
    - Averages
    - Threshold exceedances
    - Agricultural and energy indicies
  - Graphical summaries

Partnerships essential

- Bring together existing efforts, augment and ensure pull through.
  - ACRE
  - IEDRO
  - Numerous other national and international programs
- Pursue innovative approaches (crowdsourcing building upon success of oldweather.org etc.)
- Create a "land ICOADS" recognized as the repository and facilitate easy data submission
- Learn from ICOADS! ☺
- Recognize key partners and contributions

Multiple data products

- Structural uncertainty is the key (talks earlier in week …)
- Need multiple independent efforts with different choices
  - Station selection
  - Time and space resolution
  - Quality control choices
  - Homogenization decisions
  - Averaging procedures

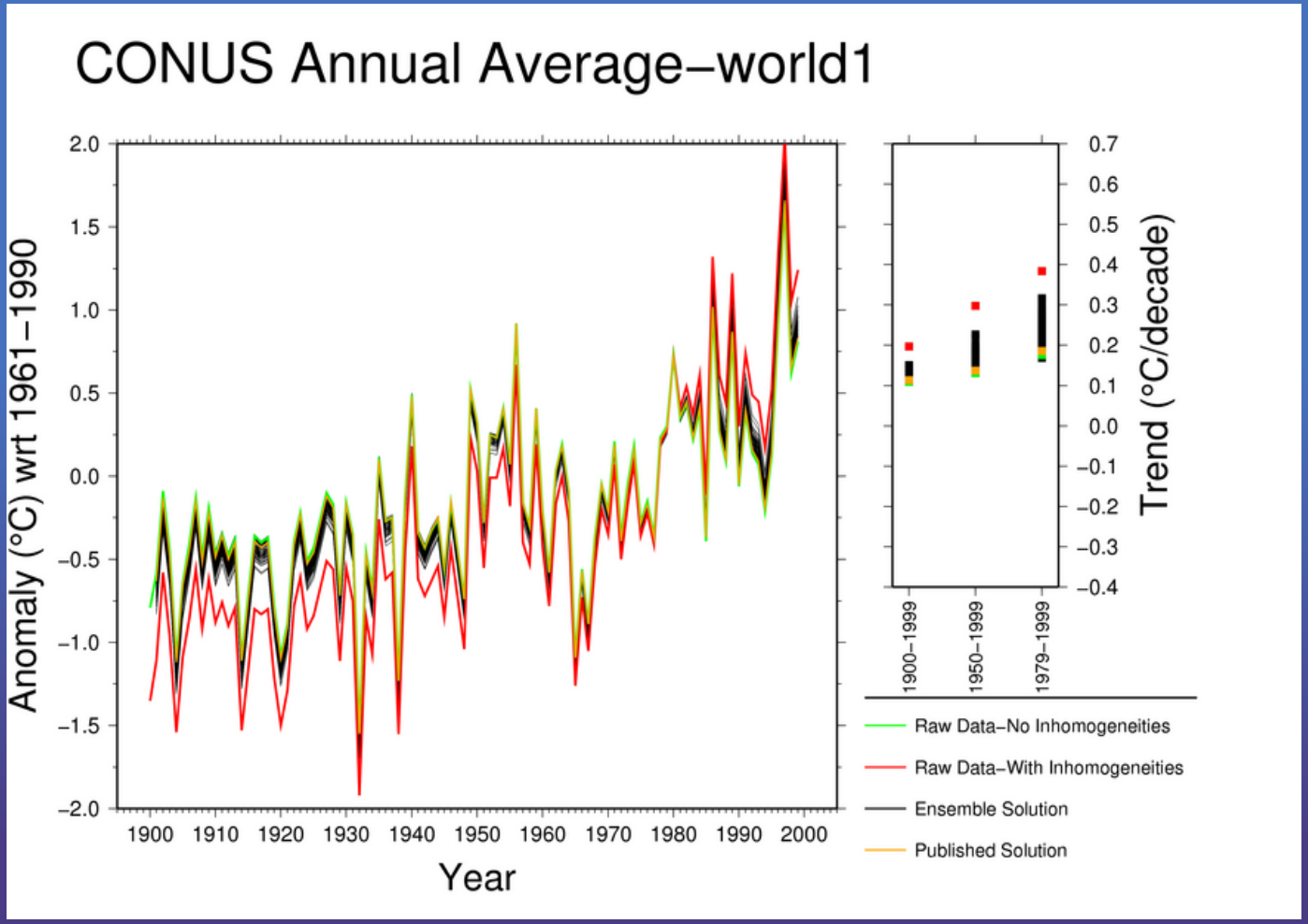
Benchmarking and assessment

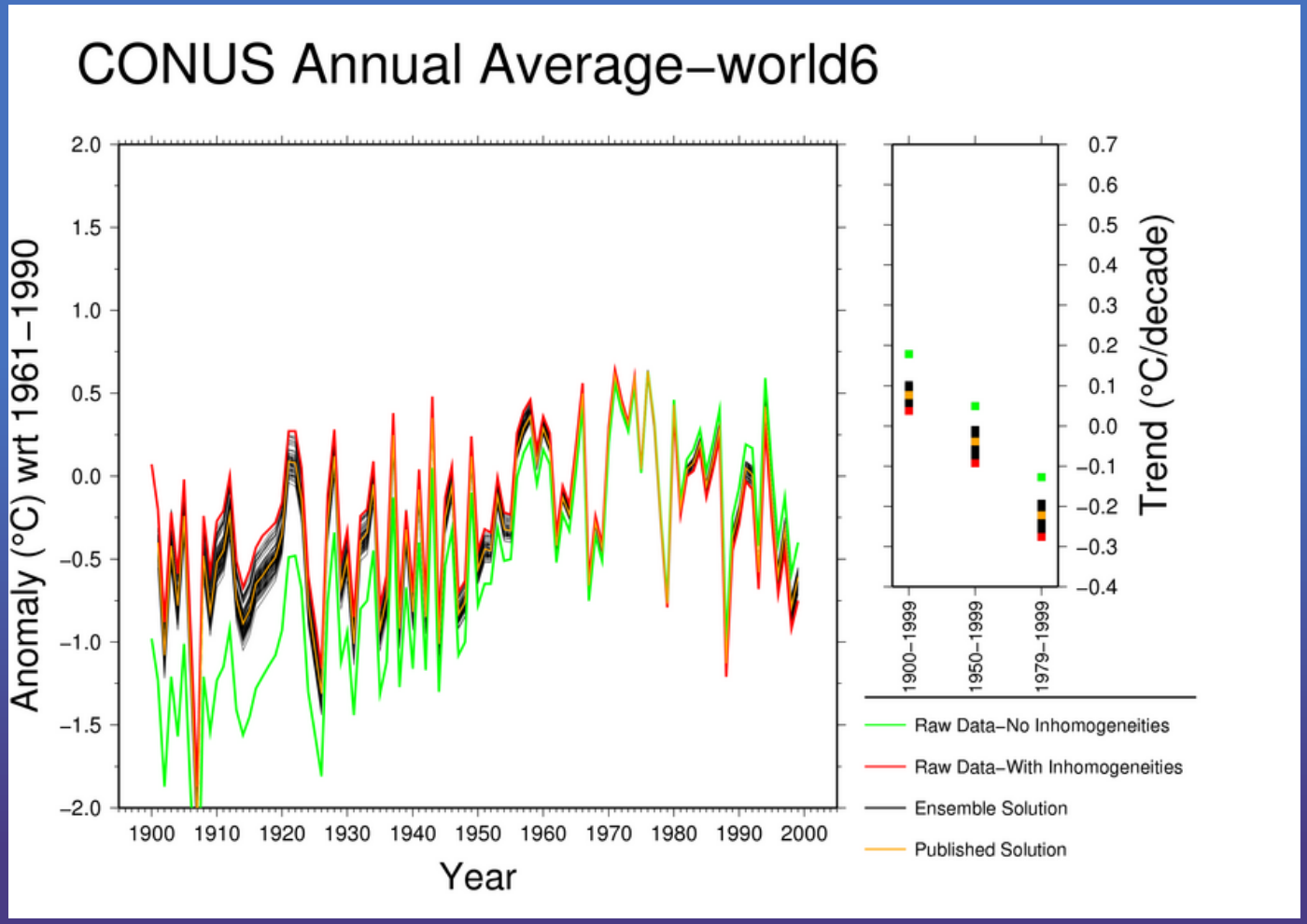
- Next talk is on this in more detail
- Real world we do not have the luxury of knowing the truth so cannot ascertain fundamental performance – "All datasets are equal …" or subjective selection which grates scientifically
- Consistent synthetic test cases potentially enable us to move to " … but some datasets are more equal than others are [for application X]"

Example

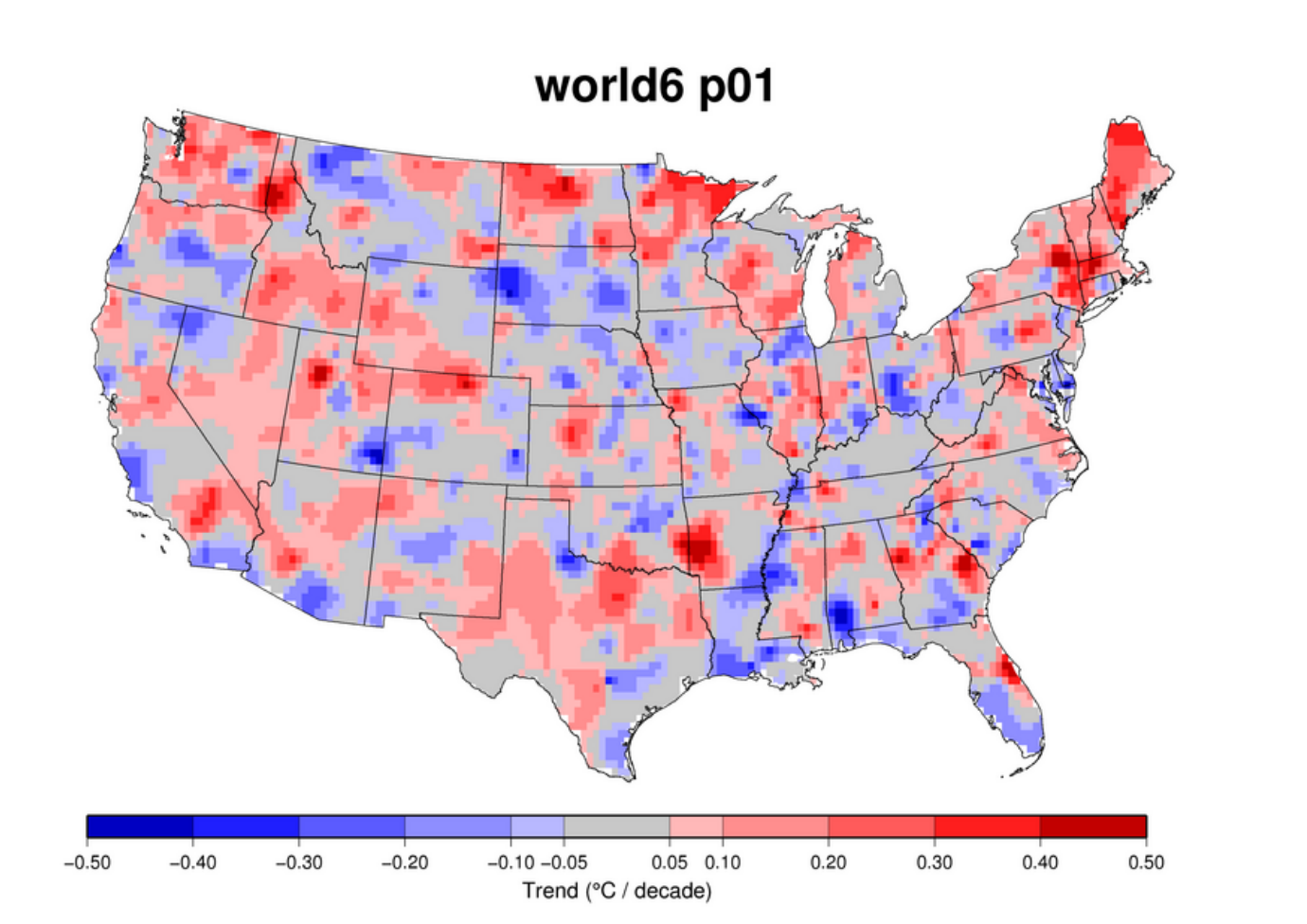
- For USHCN (lower 48 states)
- Simple benchmarks
- 100 member perturbed ensemble of the NCDC pairwise algorithm
- Consideration solely of regionally averaged timeseries and trends

Example for USHCN

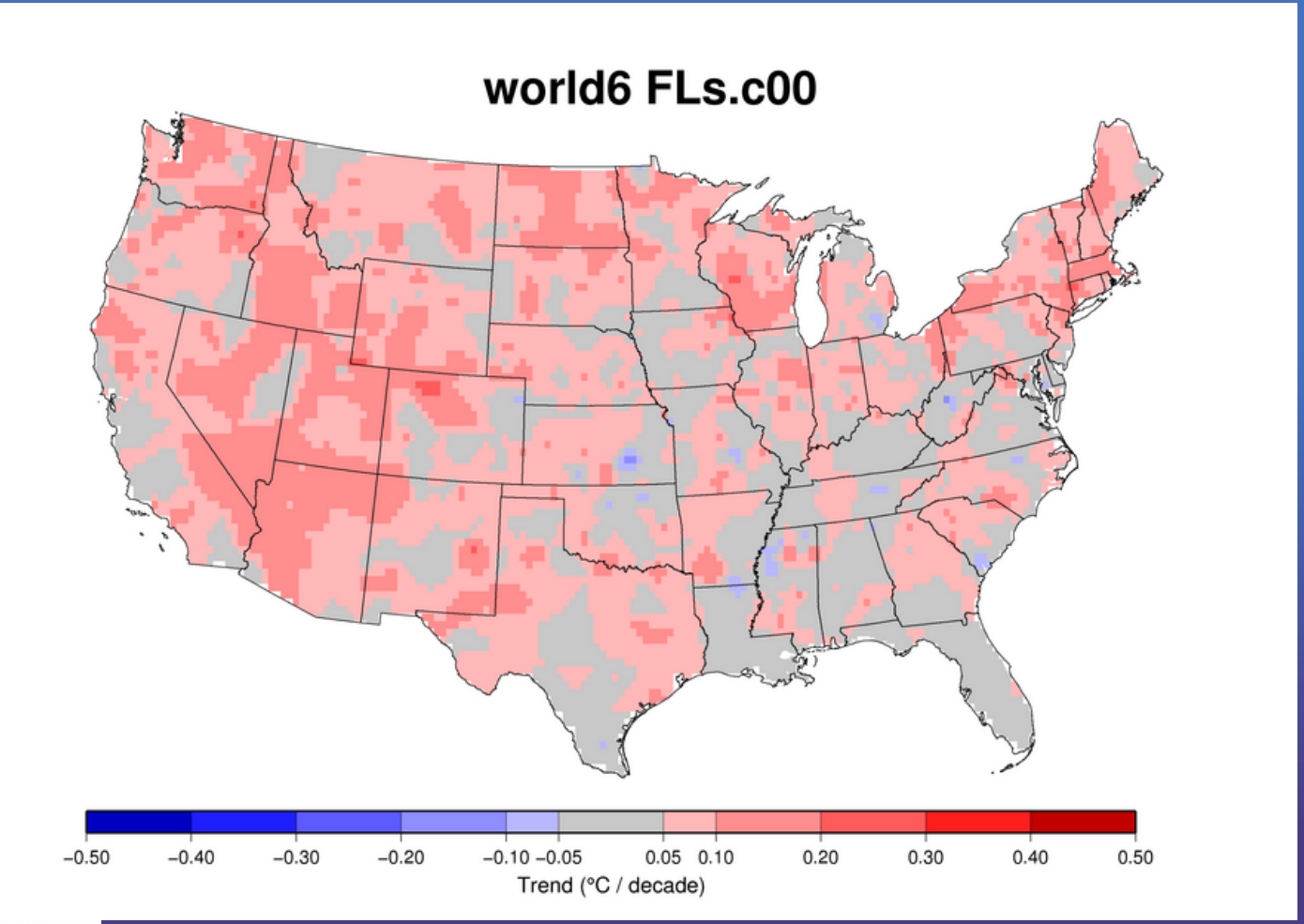



CONUS Annual Average–world6
Anomaly (°C) wrt 1961–1990
Year
Trend (°C/decade)
1900–1999
1950–1999
1979–1999
Raw Data–No Inhomogeneities
Raw Data–With Inhomogeneities
Ensemble Solution
Published Solution

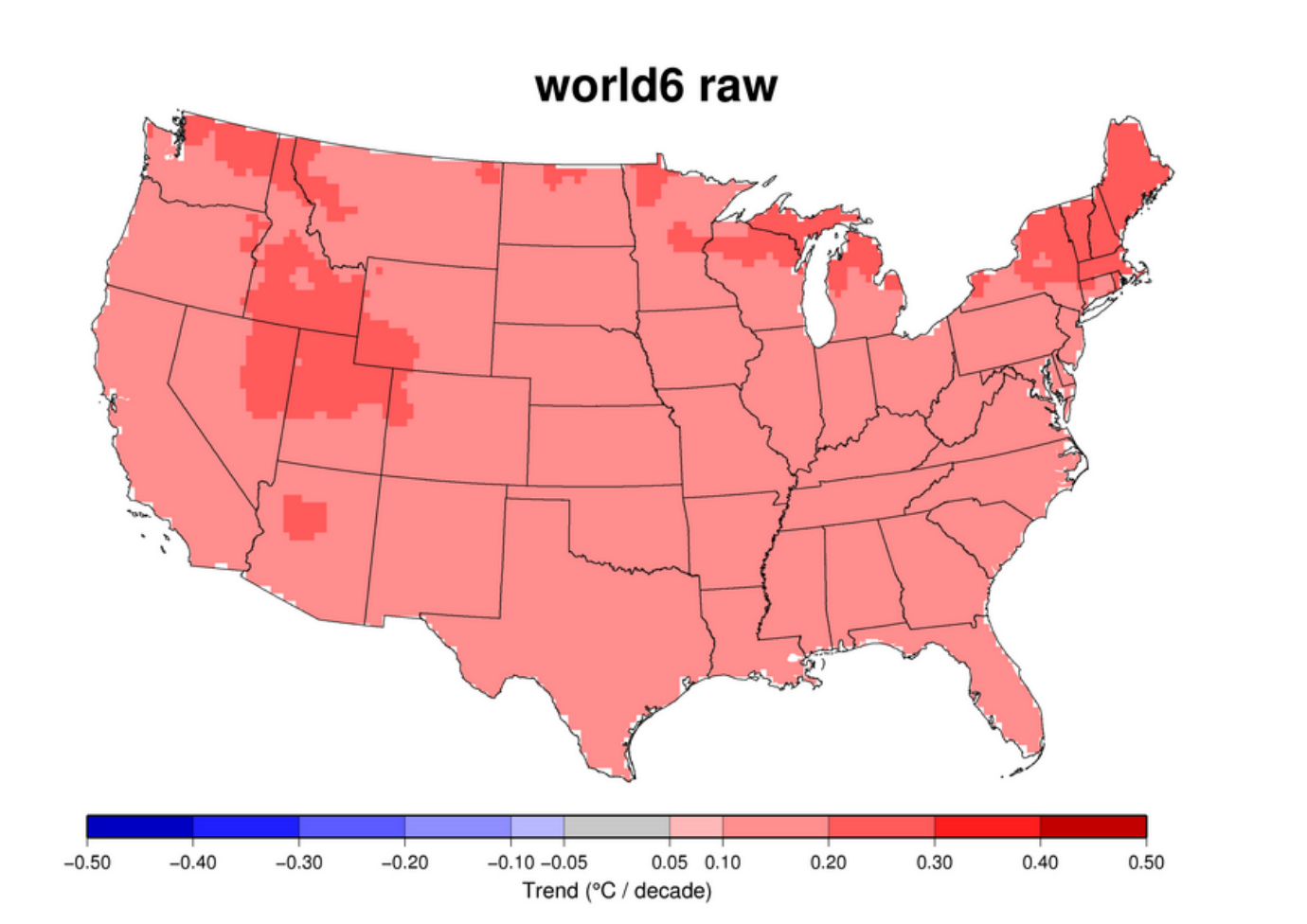
Synthetic data with added nastiness



Operational algorithm estimate



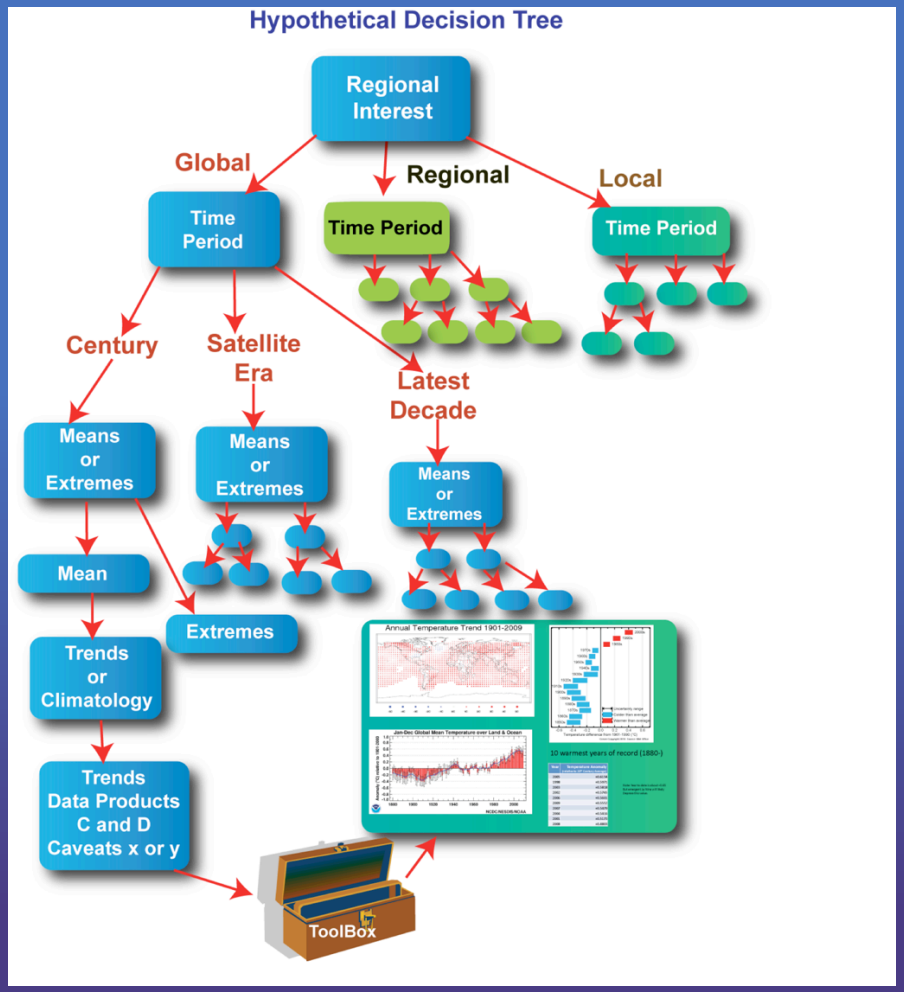
Synthetic data without nastiness



Of course …

- Better if …
  - analogs created by multi-member international team and kept blind from algorithm developers
  - Global
  - Consider more than skill at long-term trends
  - Create a science program around the analog creation and review that supports fundamental science development.

Serving products and aiding users



Open issues on data product provision

- Data formats
- Degree of user interaction
- Ability to create graphical and tabular output on the fly
- Limited progress to date
  - Largely a reflection that this data provision is some way down the road?
  - Ideas and suggestions welcome …

Overall initiative progress to date

- Steering committee set up
  - Terms of reference
  - Seeking initiative sponsor bodies (WMO, BIPM, ISI)
- Working groups on databank and benchmarking active
  - Databank prototype made public and data sources coming in.
- Implementation Plan in advance stages of drafting
- Progress documented on initiative website at www.surfacetemperatures.org

Major remaining challenges

- Beyond the obvious issue of $'s …
- Databank is, like ICOADS, going to be a multi-decade effort. Commercial considerations arguably make this harder.
- Gaining a multi-member ensemble of datasets is going to need funding and engaging multiple teams.
- Still need to resolve data serving aspects down the line

Personal thoughts on LST / SST

- People want to know changes and their uncertainties globally and regionally.
  - Need to create products that can be "merged"
    - Similar space and time steps etc.
  - Uncertainties need at a minimum to be comparable / compatible
    - Monte-carlo type ensembles of solutions would ensure calculable at any space or time scale?
    - Can we ensure the same error sources at least are considered?
    - Red noise (systematic / correlated) and white noise (random) terms both matter depending upon the application
    - BUT we can never cover every source of error?
  - Common challenges can have common solutions?
    - Interpolation
    - Averaging
    - Merging