Storm Surge Climatology: JCOMM Scientific and Technical Symposium on Storm Surges

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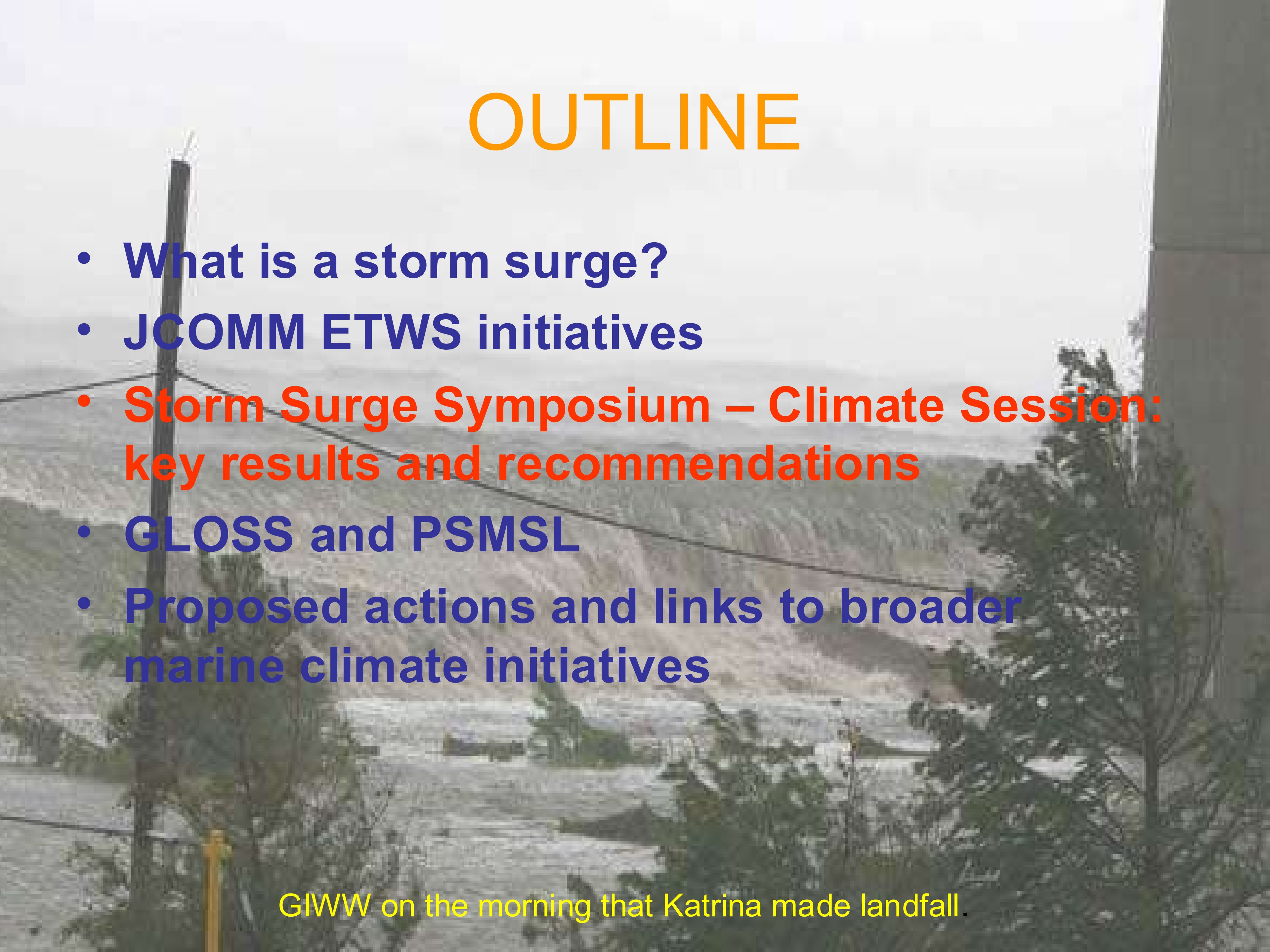
CLIMAR-III Gdynia Poland May 6-9, 2008

OUTLINE

- **What is a storm surge?**
- **JCOMM ETWS initiatives**
- **Storm Surge Symposium – Climate Session: key results and recommendations**
- **GLOSS and PSMSL**
- **Proposed actions and links to broader marine climate initiatives**



GIWW on the morning that Katrina made landfall.

DEATHS IN TROPICAL CYCLONES

May 3, 2008
Myanmar
22,500+

YEAR	COUNTRIES	DEATHS
1970	Bangladesh	300,000-500,000
1737	India	300,000
1886	China	300,000
1923	Japan	250,000
1876	Bangladesh	200,000
1897	Bangladesh	175,000
1991	Bangladesh	140,000
1833	India	50,000
1864	India	50,000
1822	Bangladesh	40,000
1780	Antilles(West Indies)	22,000
1965	Bangladesh	19,279
1999	India	15,000
1963	Bangladesh	11,520
1961	Bangladesh	11,466
1985	Bangladesh	11,069
1971	India	10,000
1977	India	10,000
1966	Cuba	7,196
1900	USA	6,000
1960	Bangladesh	5,149
1960	Japan	5,000
1972	India	5,000

Storm Surge

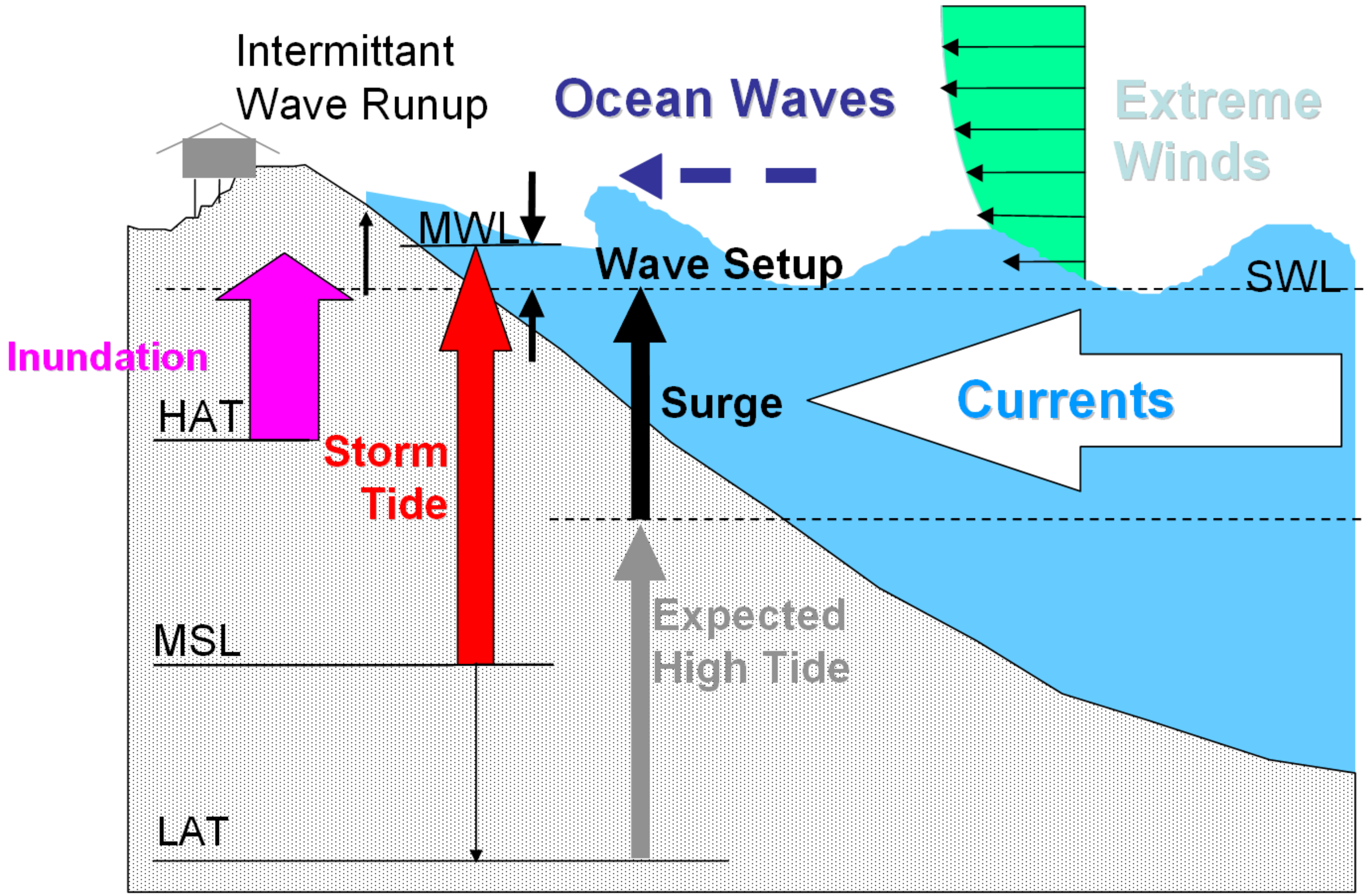
Oscillations of the water level in a coastal or inland water body in the period range of a few minutes to a few days as a result of forcing from atmospheric weather systems.

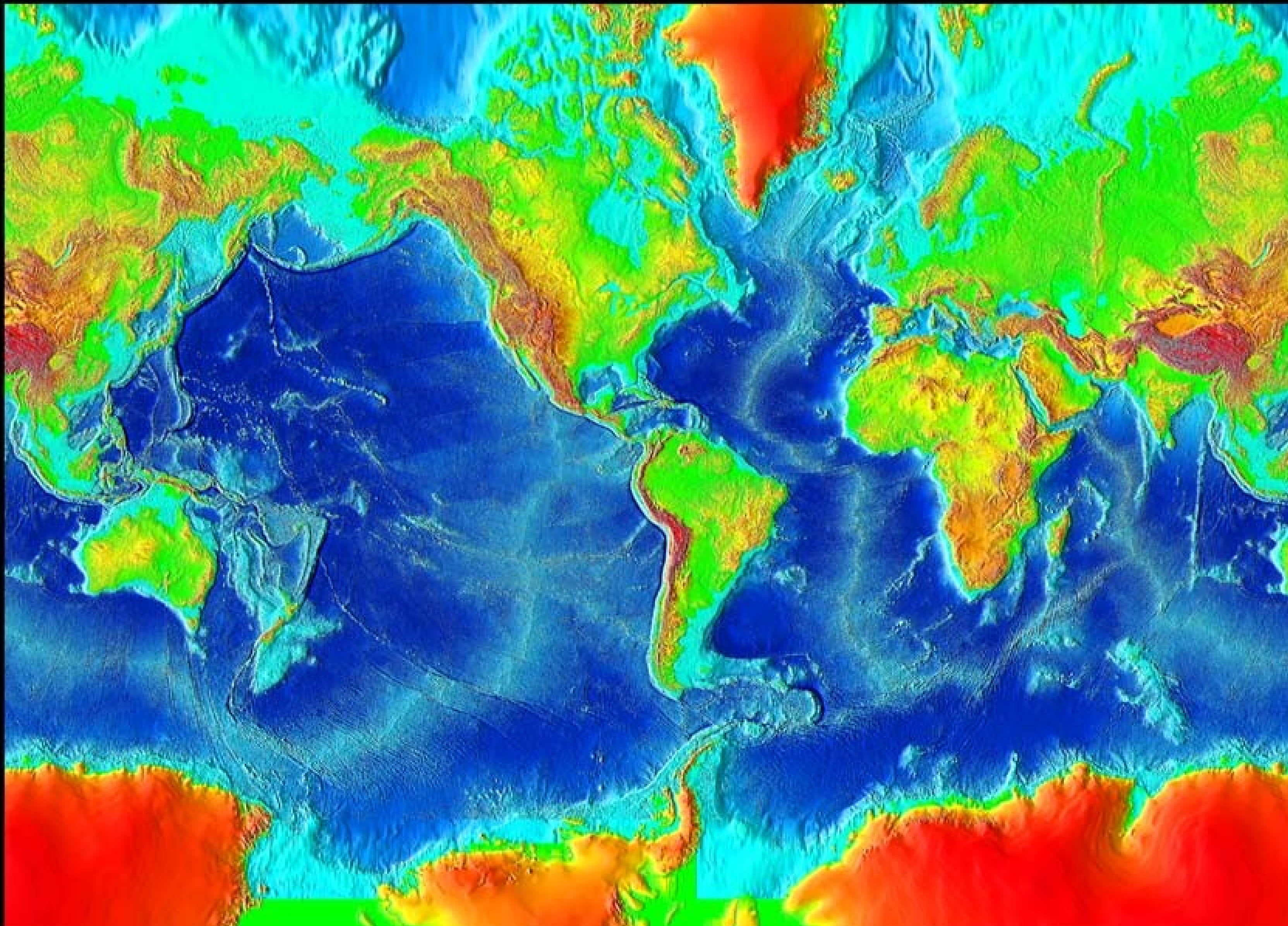
“Storm tide" is the combined water level associated with the simultaneous effects of the astronomical tide, storm surge and breaking wave set-up.

Surge can be measured directly at coastal tidal stations as the difference between the forecasted tide and the observed rise of water.

- Tropical or extratropical cyclones
- Remote or meso-scale forcing
- Continental shelf waves, edge waves and topographically forced Rossby waves

Water Level Components of a Storm Tide





Surges may be negative or positive

Positive surges cause most of the destruction and loss of life on land

Negative surge impacts are mostly economic, e.g. in harbour approaches

JCOMM ETWS: Basic Information on Storm Surges (18)

Stations	Param	Period	Instr	Dig/ Analog	Metadata	Climatology	Country
170	SL; curr	1845-P 1950-P	Tide curr. met. ADCP	A D	SL: other inst curr	Extreme value analysis	Germany
21	SL	1992-P	15 acous 7 pres	D	Sensors, units, models	Trends, extremes, regimes	Spain
25	SL	1970-P	well type radar (3)	D	Web based	Max SL return period	Korea
18	SL	~ 1900	well type	D	-	No	Sweden
-	SL	-	NA	D	-	-	Canada
2	SL	1986-P	Stevens type A	D/A	-	yes	Mauritius
66	SL	1960-P	float 12 acous 1 press	D	location, datum vs ground	maxima	Japan
1	curr	2002-P	ADCP	D	document	-	Slovenia

JCOMM ETWS: Hindcasted databases on storm surges (12)

Source	Model	Period	Country
EU HIPOCAS proj. operational	HAMSOM Nivmar	1958-2002 1998-present	Spain
EU STOWASUS-2100	climate storm surge model non oper.	web.dmi.dk/pub/STOWASUS-2100/	Denmark
Events - case studies	Operational	1998-present	Japan
Case studies	Operational	1997-present	Korea
Continuous; case studies	Operational	2002-2004 2005-present	Argentina
Case studies	Operational	1962 - 1999	Germany
Case studies; simulations	Operational	1940-2004	Kazakhstan
Case studies	Operational	1999	France
Extensive	Operational	1947-2004	Hong Kong
extensive and case studies	Operational	1948-2004	Russia
Maximum envelope of surge water	-	-	India
EU STOWASUS	-	-	United Kingdom

Symposium on Storm Surges - Session 8
Storm Surge Climate and Climate Change

- **8.1** ***Extreme Sea Levels, Coastal Flooding and Climate Change*****;** Keith Thompson, Dalhousie University
- **8.2** ***Assessing the impact of climate change on storm surges in southern Australia;*** Kathleen McInnes, CSIRO
- **8.3** ***Impact on the global warming on the intensity of future tropical storm*****;** Jai-Ho Oh, Pukyong National University
- **8.4** ***Spatially high resolved projections of possible future changes in North Sea storm surge extremes;*** Katja Woth, GKSS Research Center
- **8.5** ***Exploring the feasibility of regional typhoon modelling;*** Frauke Feser, GKSS Research Center
- **8.6** ***Statistics of abnormal sea states around Korean Peninsula*****;** Jong Chan Lee, KORDI
- **8.7** ***Storm Surges in Tideless Seas - Southern Baltic Sea;*** Marzenna Sztobryn, Institute of Meteorology and Water Management

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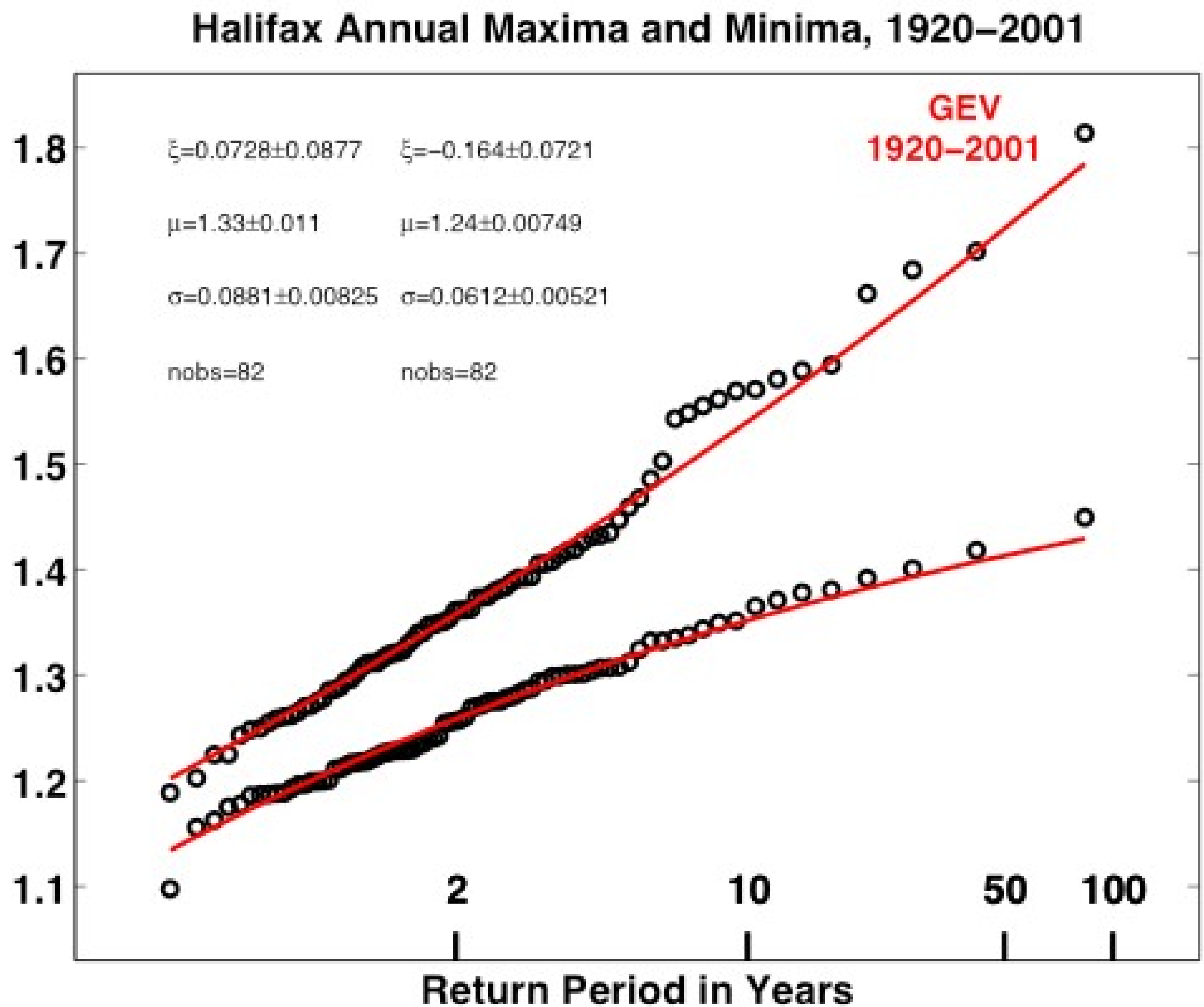
- **9.1** ***Developments in storm tide modelling and risk assessment in the Australian region;*** Bruce Harper, Systems Engineering Australia Pty Ltd.
- **9.2** ***A surge response surface approach to the estimation of surge hazards in the vicinity of New Orleans;*** Donald Resio, US Army Corps of Engineers

Classical Analysis of Extremes



Return Level plot: Return level against return period, assuming Type I

Can We Recover The Distribution of Extremes Using the Barotropic Model?

Model: Outer surge model, run from 1960 to 1999

Winds: AES40, 6h, 1958-2000, 0.63º (lat) and 0.83º (lon)

Air pressure: Estimated from winds to within 3mb

Output: Hourly hindcasts stored for each grid point

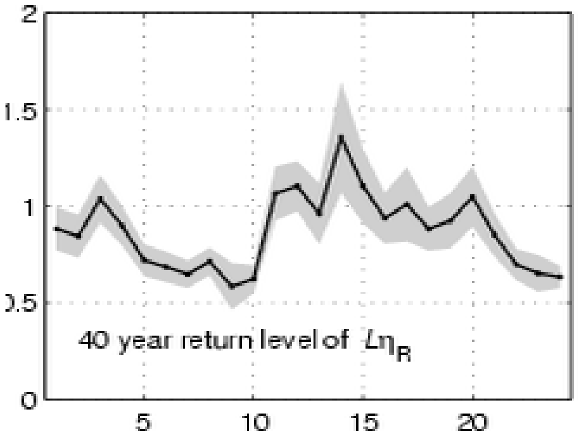
Analysis: Gumbel distribution fit to annual maxima

For details see:

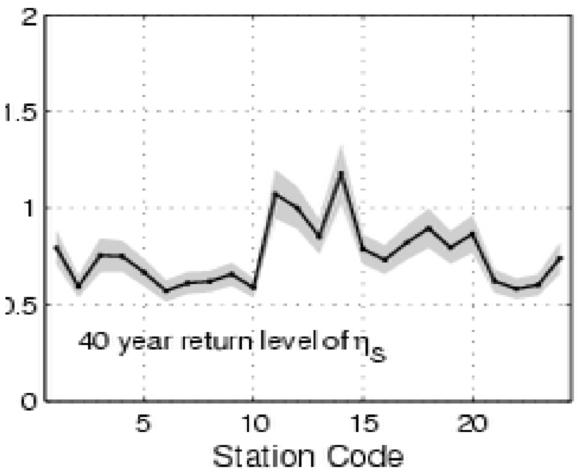
Bernier, N. and K. Thompson, 2006. J. Geophys. Res., (2006), 111, C10009.

40 Year Return Levels for Storm Surges

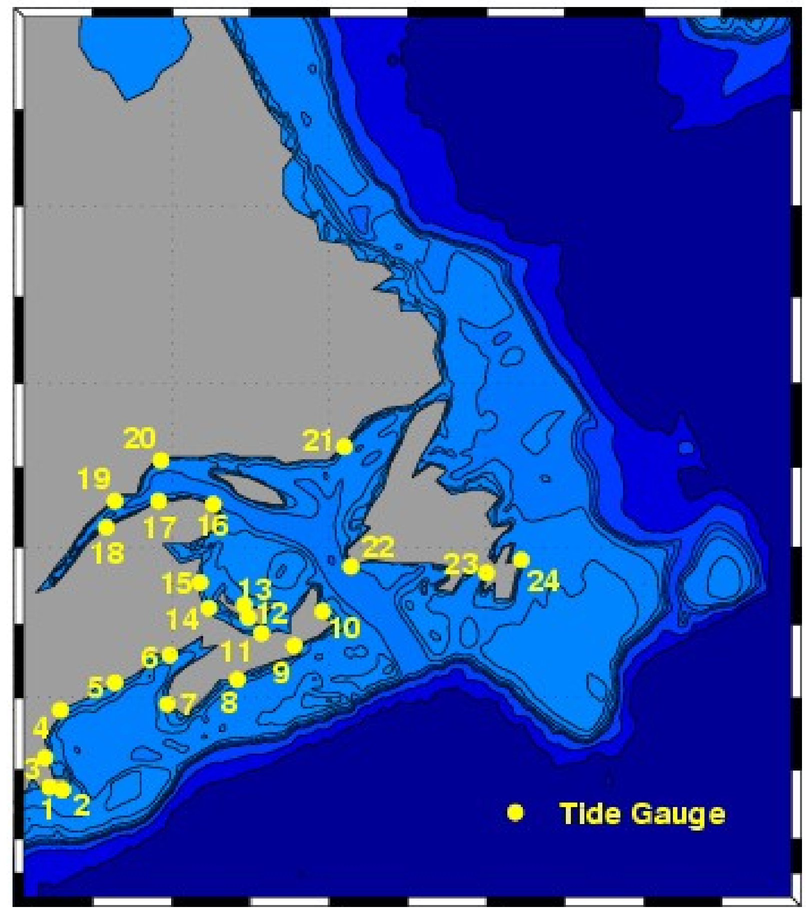
Observed



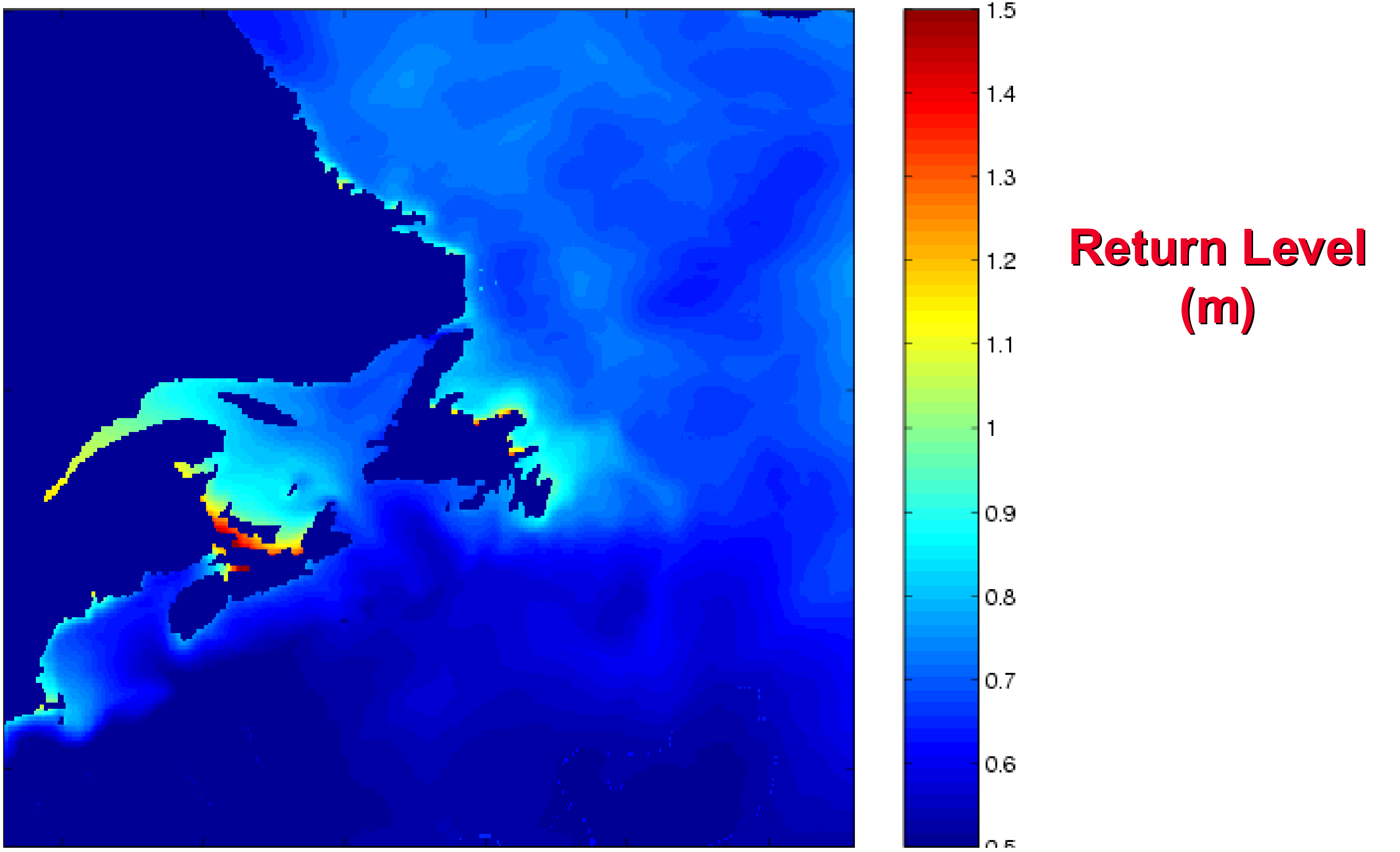
Predicted



Station Number



40 Year Return Level for Storm Surges

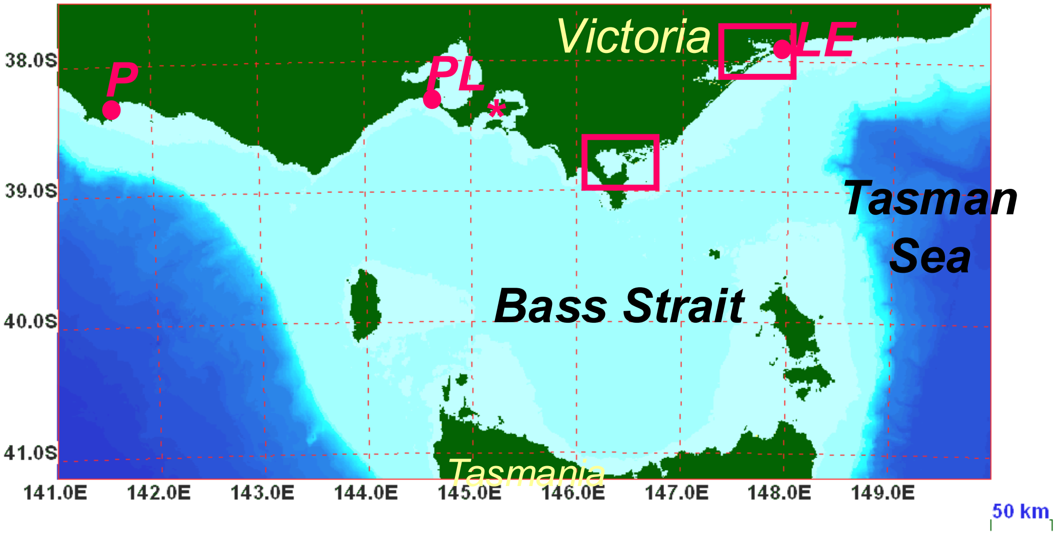


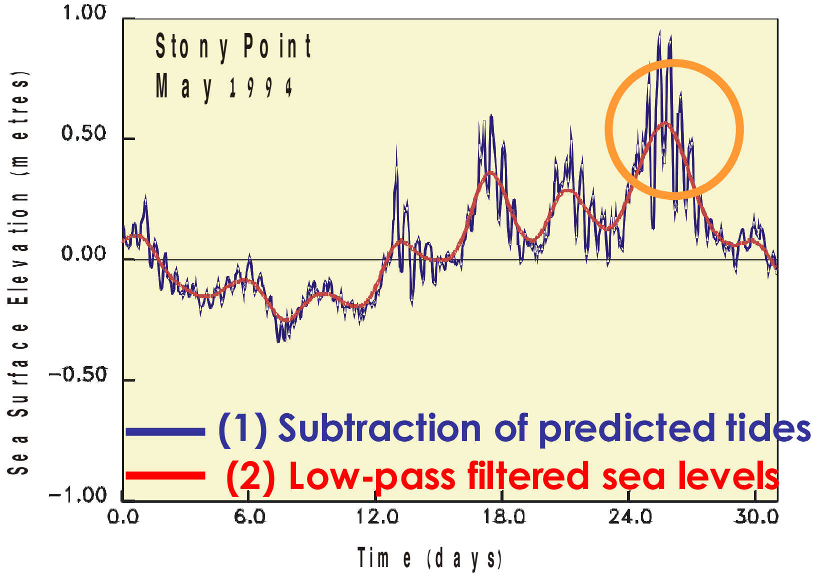
Method (1)

Storm surge return periods:

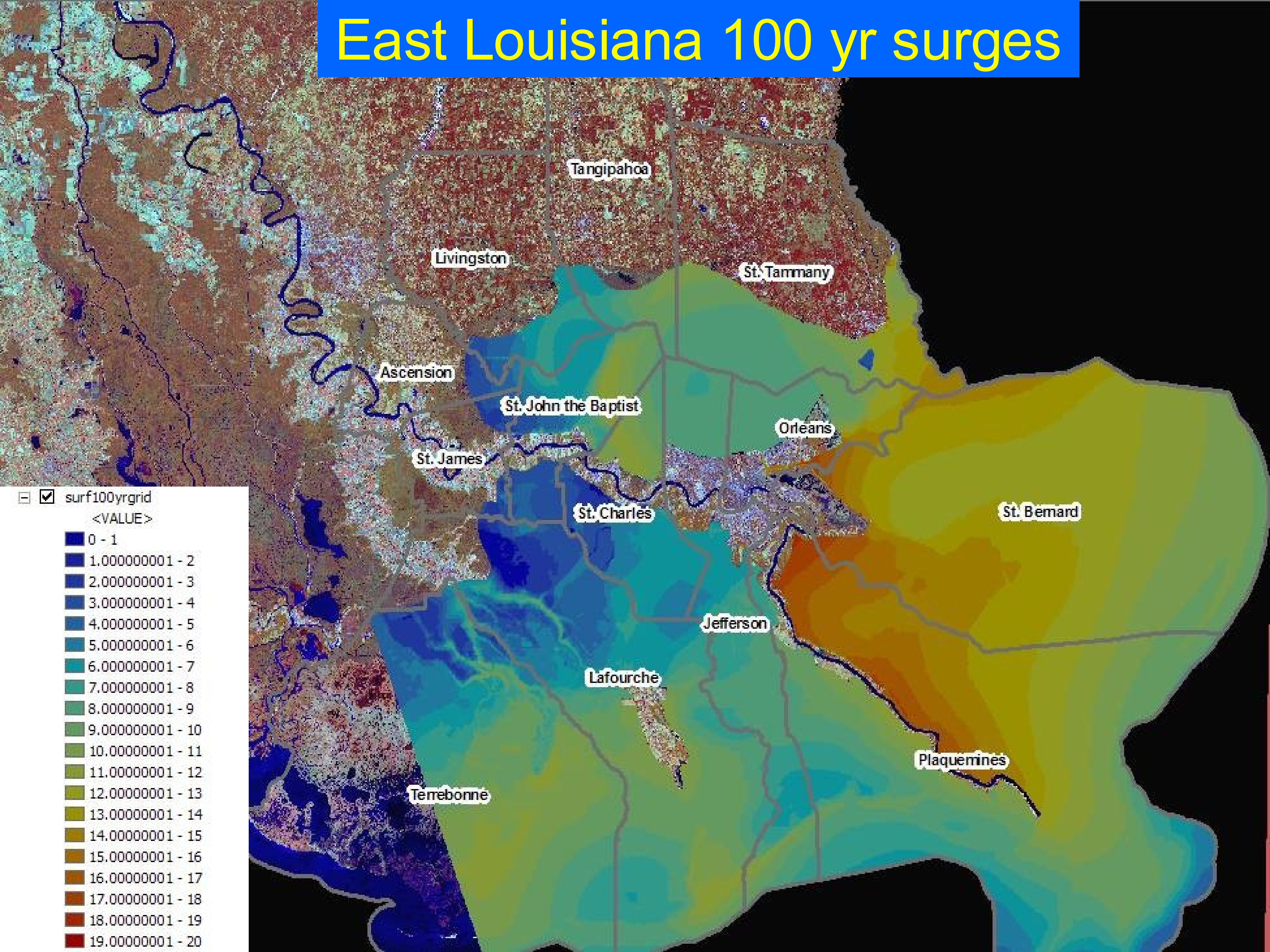
Hydrodynamic modelling and extreme value statistical analysis to evaluate storm surge return levels from observed set of events

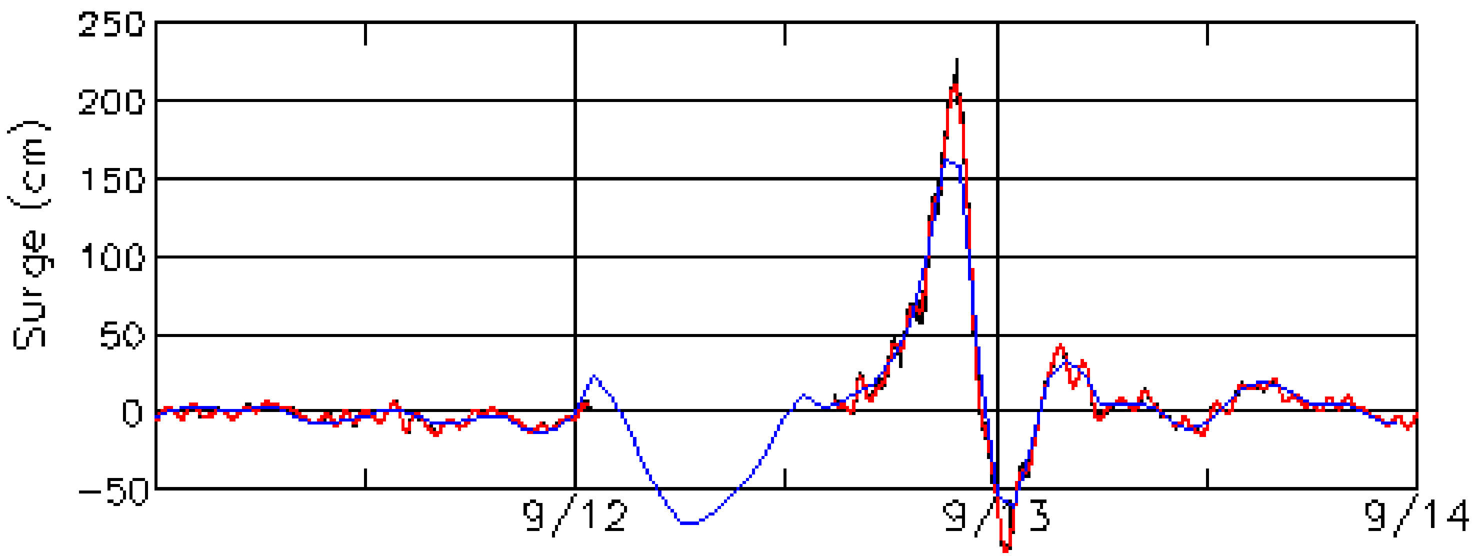
- **Three tide gauge records used for event selection**
- **Tidal signal removed using low pass filter**
- **Threshold approach used to select events (489 events identified from 38 years of data)**





East Louisiana 100 yr surges



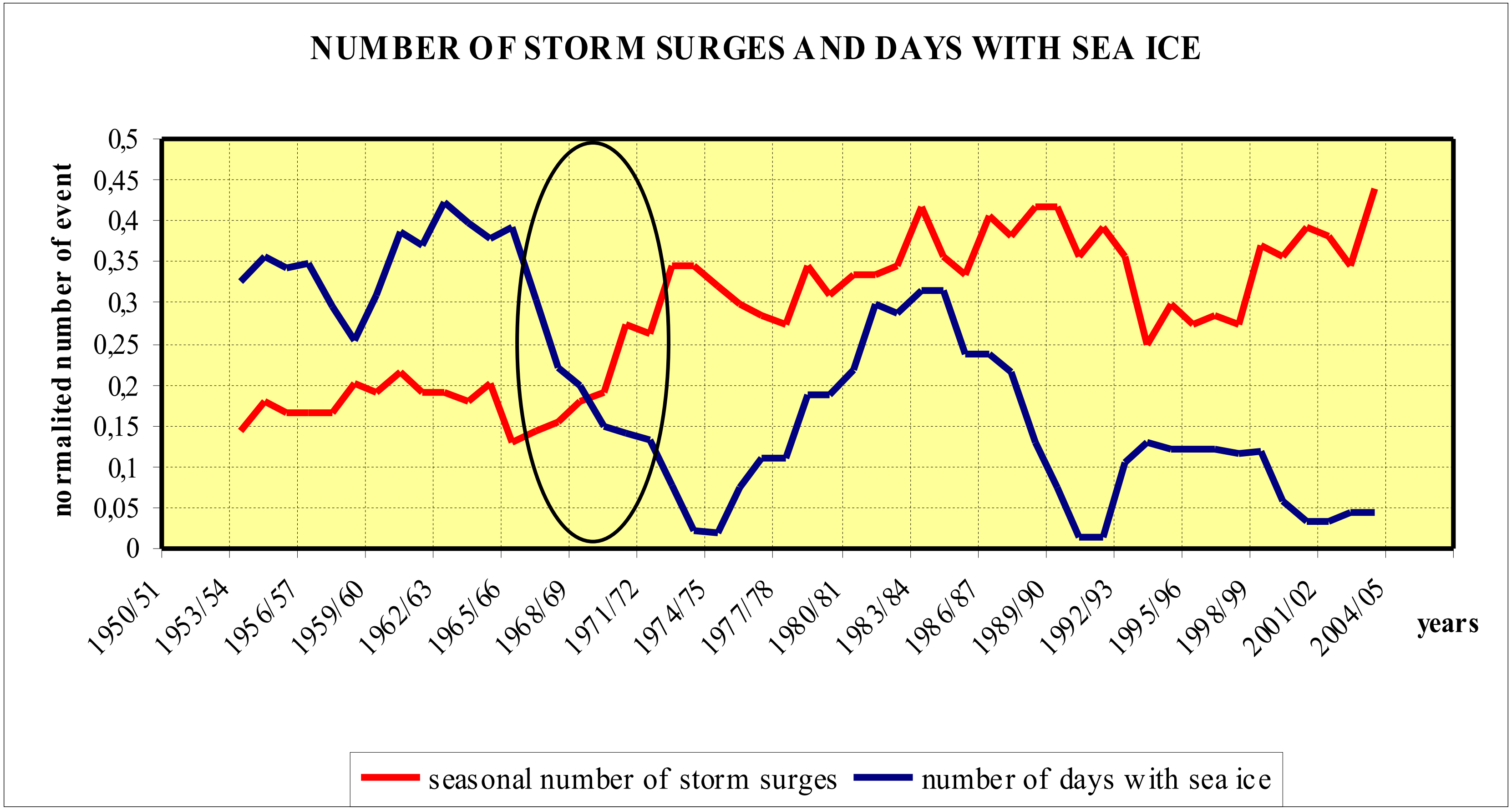


Storm surge at Masan during typhoon Maemi (Black : 1 minute raw SSH, Red : 1 minute filtered SSH, Blue : 1 hour SSH)

Maximum surge Heights Based on 1 year HM :
162 cm (1 hr), 226 cm (Raw), 211 cm (filtered)

STORM SURGES IN TIDELESS SEAS - SOUTHERN BALTIC SEA

NUMBER OF STORM SURGES AND DAYS WITH SEA ICE



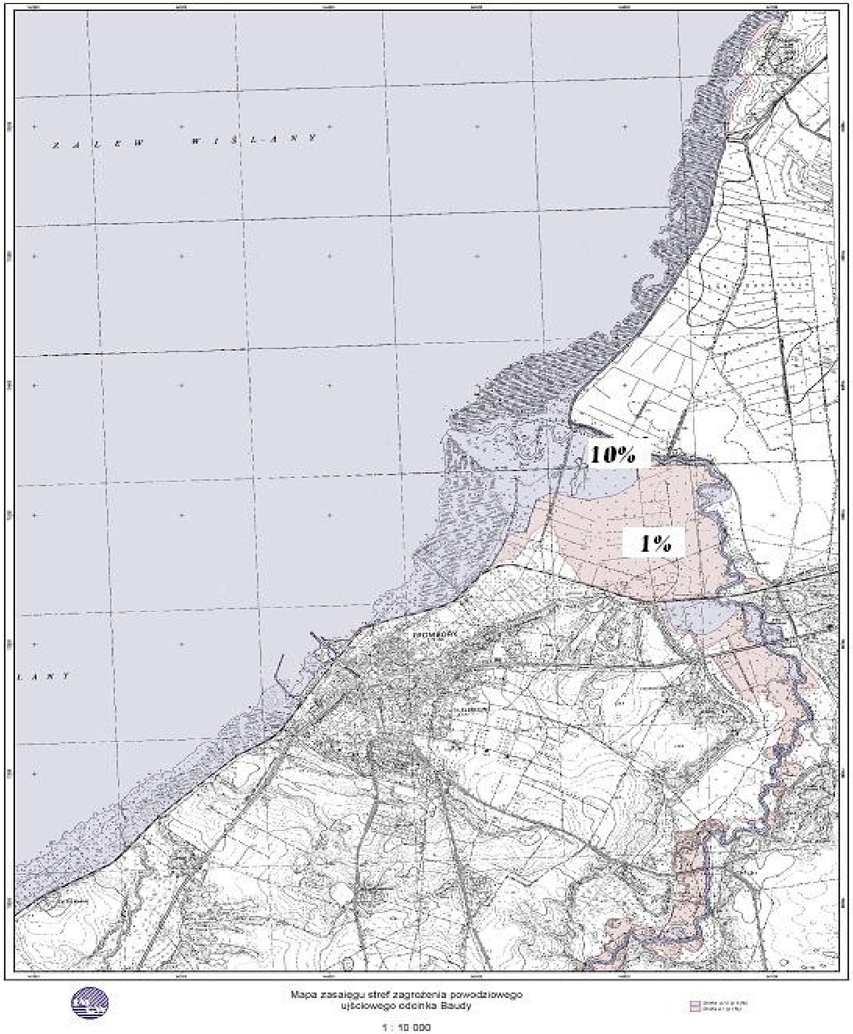
INUNDATION MAPS

1. **by probability of occurrence**
   10%
   1% and
   0,5% (hot spot),

2. **Hypothetical storm *by* forecast model**
   input data consisted of values from the most unfavorable boundary conditions known to have occurred in area

3. **Max SL even observed+linear trend**

COUPLED HYDROLOGICAL MODELS : HEC-RAS (HD); MIKE11(HD,P)



JCOMM Symposium on Storm Surges
Agreed Recommendations and Actions

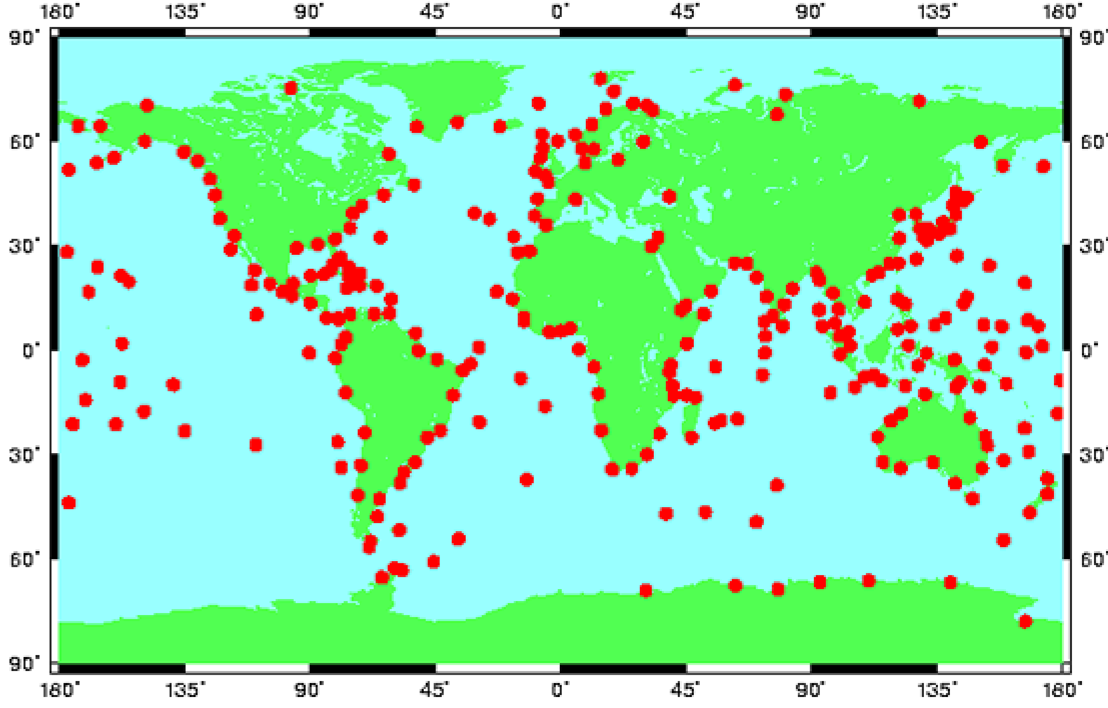
Observations and Data	
National access to, or development of, high resolution, near shore, bathymetric data and coastal zone topographic data sets highly desirable	National agencies Space agencies
Enhanced GLOSS network to support storm surge risk assessments, research and forecasting, with recommended 1 minute sampling	JCOMM/GLOSS GE
Enhance in situ networks for all relevant variables, including higher time resolution	National agencies
Look to utilize other observation platforms to enhance in situ data; e.g. tsunameters	National agencies, JCOMM and Secretariat
Countries should prioritize data acquisition on the basis of risk analysis, including vulnerability and hazard impact probability	National agencies
Global access to existing storm surge data sets, perhaps through a storm surge metadata catalogue; Development of interoperable storm surge databases and climatologies	JCOMM/ETWS, Secretariat

JCOMM Symposium on Storm Surges Agreed Recommendations and Actions (2)

Future Research and Development	
Improved physics and physical processes in the models; e.g. wave/current and wind/current interactions	SS research community
Need development of fully coupled basin / coastal / tide / wave / atmosphere models and programme for continuous improvement	
Improvements required in total water level predictions as a result of tide, wave and surge interactions	
Coupled hydrologic, hydraulic and surge models for inundation	
Research required on mesoscale wind forced events and remotely forced inundation events	
Develop methodologies to project changes in storm surge climate over the next century, with associated measures of uncertainty	
Further development of empirical techniques, e.g. AI, neural networks, statistical	
Investigate improved means to incorporate uncertainty into forecast guidance	
Pursue studies of model sensitivity to spatial and temporal resolution for	

Global Sea Level Observing System

- GLOSS aims at the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research.
- The main component of GLOSS is the 'Global Core Network' (GCN) of 290 sea level stations around the world for long term climate change and oceanographic sea level monitoring.



Access to Sea Level Data

- **PSMSL** is the global data bank for long term sea level change information from tide gauges. **Monthly and annual** mean values are available online at **www.pol.ac.uk/psmsl/**
- **High frequency** sea level data (typically hourly values) is more complicated to obtain than MSL data due to perception of either military or commercial value (unlike MSL). This situation has improved in recent years.
- There is still no single global data centre for HF data, but considerable data is available from British Oceanographic Data Centre (BODC), and University of Hawaii Sea Level Center (UHSLC) which has its Research Quality Data Set (RQDS) which is, to a great extent, a GLOSS DM HF data set.
- Steps are now being taken to merge these 2 DM HF data sets as far as possible for the benefit of users.
- Aside from GLOSS, a user wanting HF data from a particular region must consult one of a number of national and international (regional) data centres, in different formats and possibly subject to a charge.

What Next?

- Develop a global storm surge data base,
  - for calibrating numerical models, background data to infer the influence of climate change on storm surges generated by tropical and extra-tropical cyclones. – de-tide GLOSS HF 1-hour record
- Develop new storm surge models for meso-scale and remote forcing.
- Upgrade storm surge models to include effects of continental shelf waves, edge waves and topographically forced Rossby waves.
- Encourage additional storm surge hindcast climatologies
- Document storm surge data bases (sea level) and hindcasts in JCOMM catalogues
- Develop possible indices and link with ETCCDI
- Establish stronger links with GLOSS

Plaquemines ParishRoadway on Levee

Storm Surges vs. Tsunamis

Similarities

Long gravity waves.

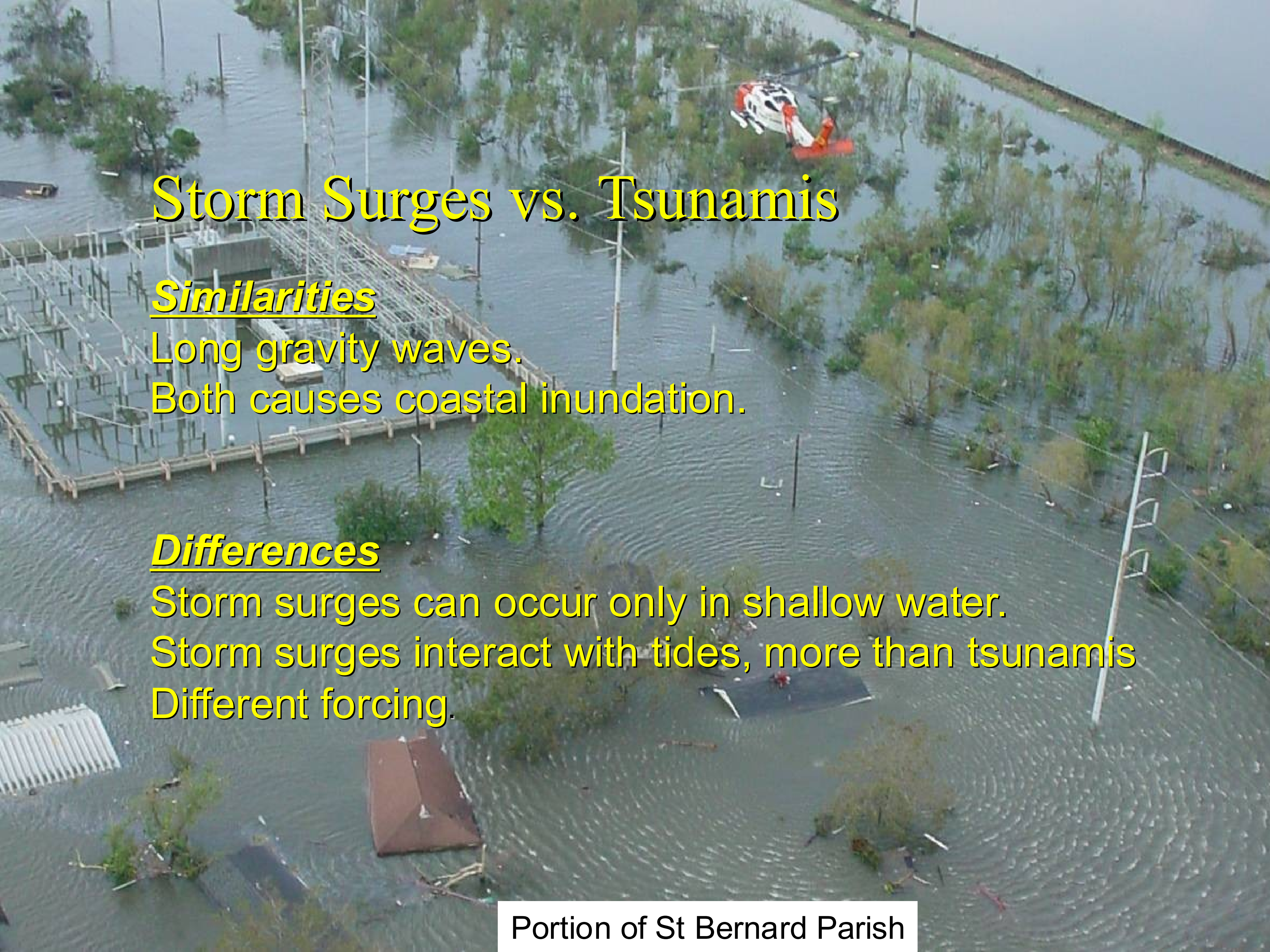
Both causes coastal inundation.

Differences

Storm surges can occur only in shallow water.

Storm surges interact with tides, more than tsunamis

Different forcing.



Portion of St Bernard Parish

Program - JCOMM Scientific and Technical Symposium on Storm Surges

2 - 6 October 2007, Seoul, Korea Rep

- 0.2 Storm Surge Manual
- 0.1 Introduction of JCOMM activities
- 0 Introduction
- 1 Storm Surge Modelling
- 2 Operational Storm Surge Forecasting
- 3 MetOcean Forcing
- 4 MetOcean Forcing Observations
- 5 Regional Studies
- 6 Regional Application
- 7 Case Studies
- **8 Storm Surge Climate and Climate Change**
- 9 Risk and Impacts
- 10 Poster Session

Symposium Web site at surgesymposium.org

PSMSL sites

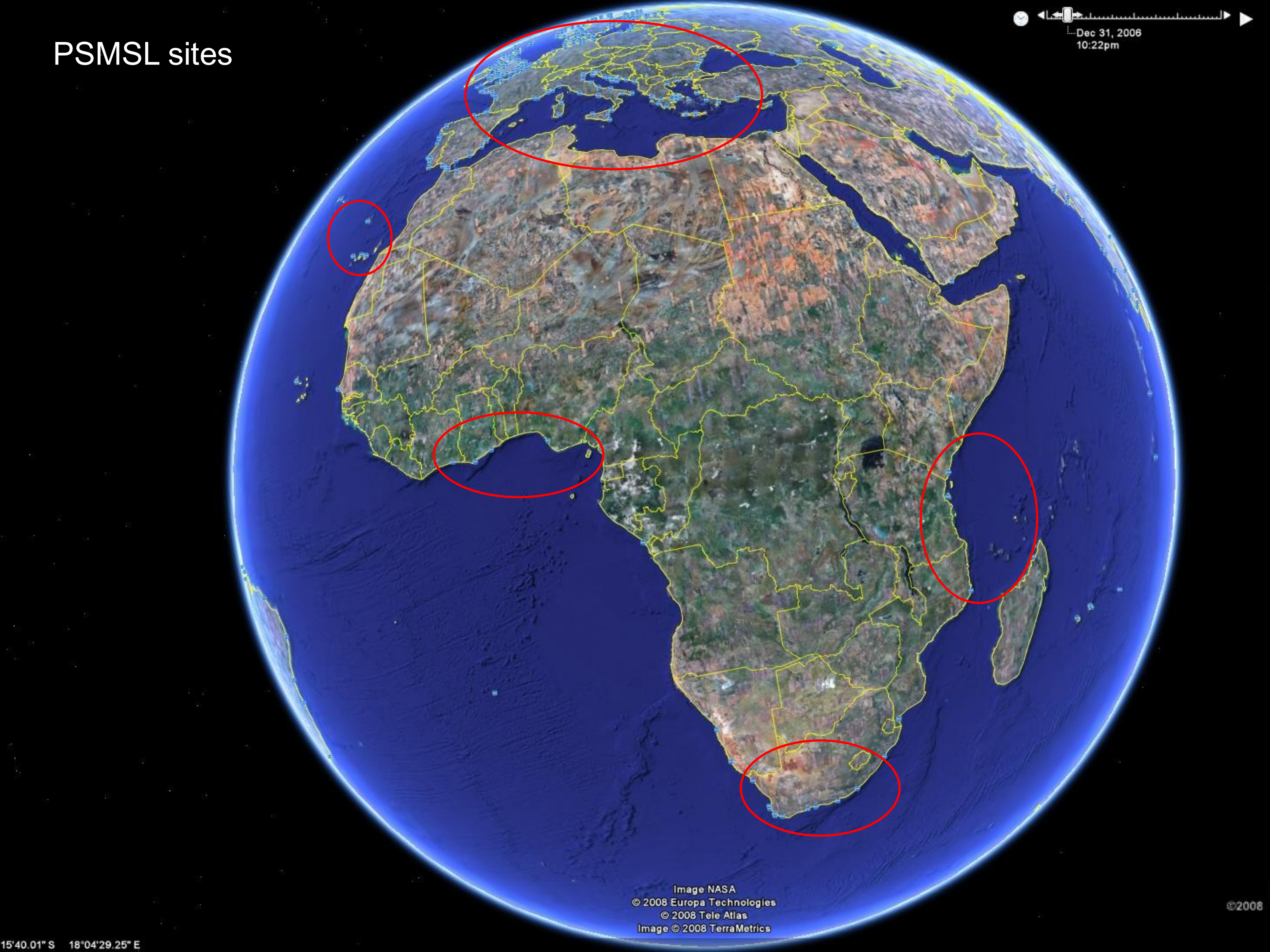

Dec 31, 2006
10:22pm
Image NASA
© 2008 Europa Technologies
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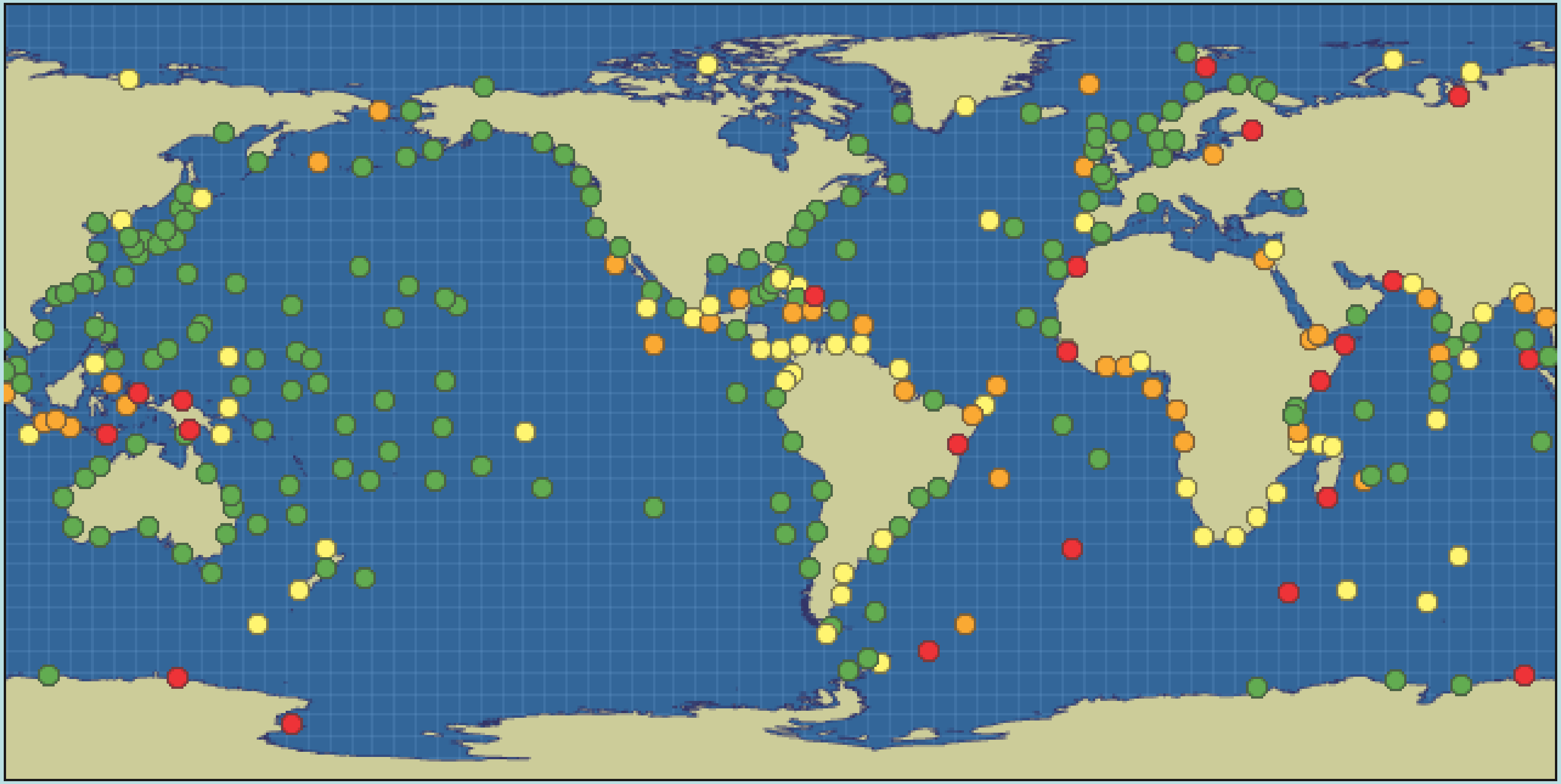
Image © 2008 TerraMetrics
©2008
15'40.01" S 18°04'29.25" E

GLOSS status within the PSMSL data set - October 2007



Category 1: "Operational" stations for which the latest data is 2003 or later

Category 2: "Probably operational" stations for which the latest data is within the period 1993-2002.

Category 3: "Historical" stations for which the latest data is earlier than 1993.

Category 4: "Stations for which no PSMSL data exist.