8th International Workshop on Wave Hindcasting and Forecasting

Forecast Divergences of a Global Wave Model

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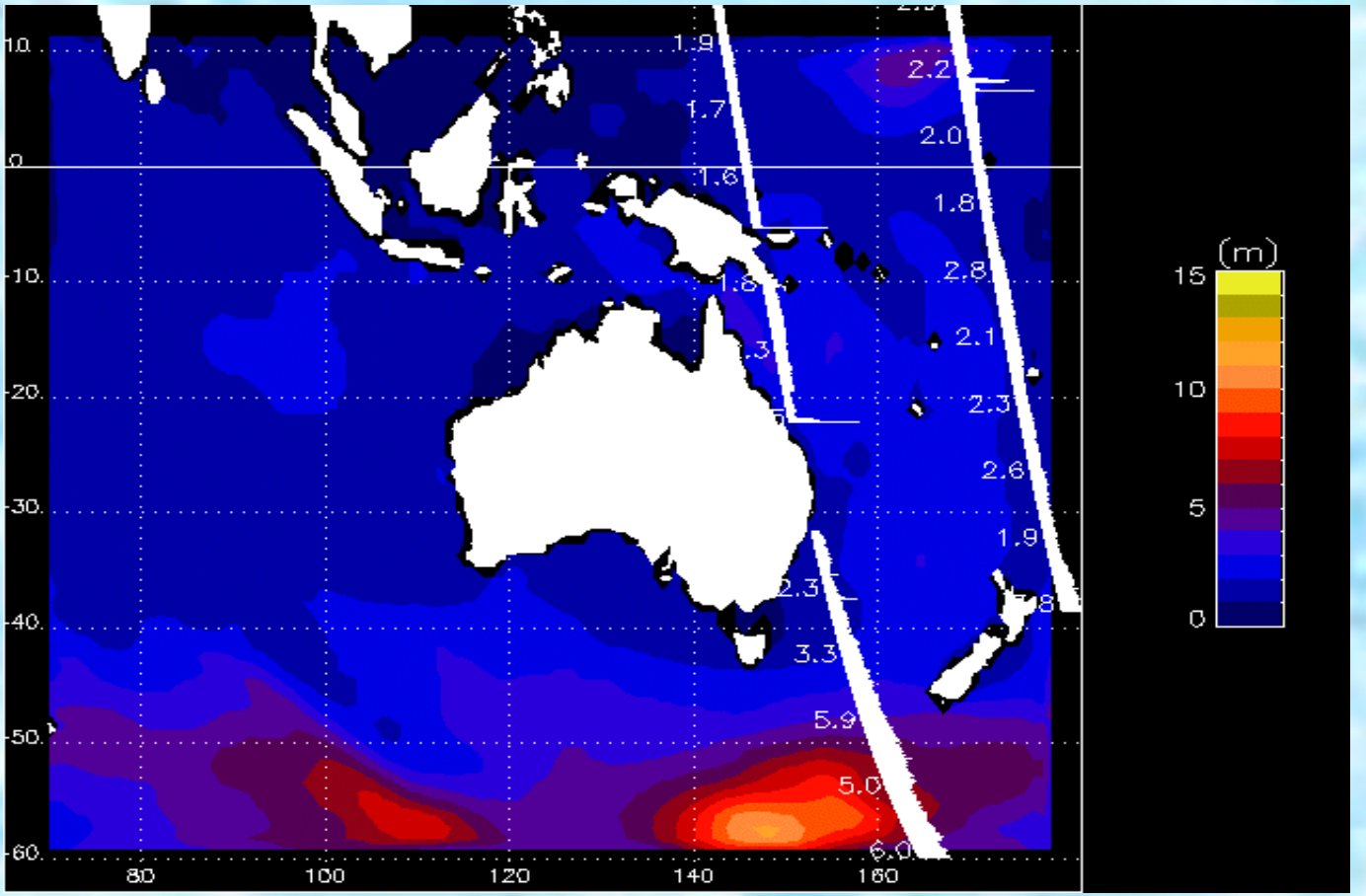
Outline

- Motivation
  - How best to use observations in wave model data assimilation systems?
- Method
  - NMC method – spatial correlations of forecast differences
- Results
  - Isotropic/Anisotropic
  - Forecast period
  - Seasonal variability
- Summary

Motivation


10
0
10
20
30
40
50
60
80
100
120
140
160
1.9
1.7
1.6
1.8
1.8
2.2
2.0
1.8
2.8
2.1
2.3
2.6
1.9
2.3
3.3
5.9
5.0
6.0
(m)
15
10
5
0

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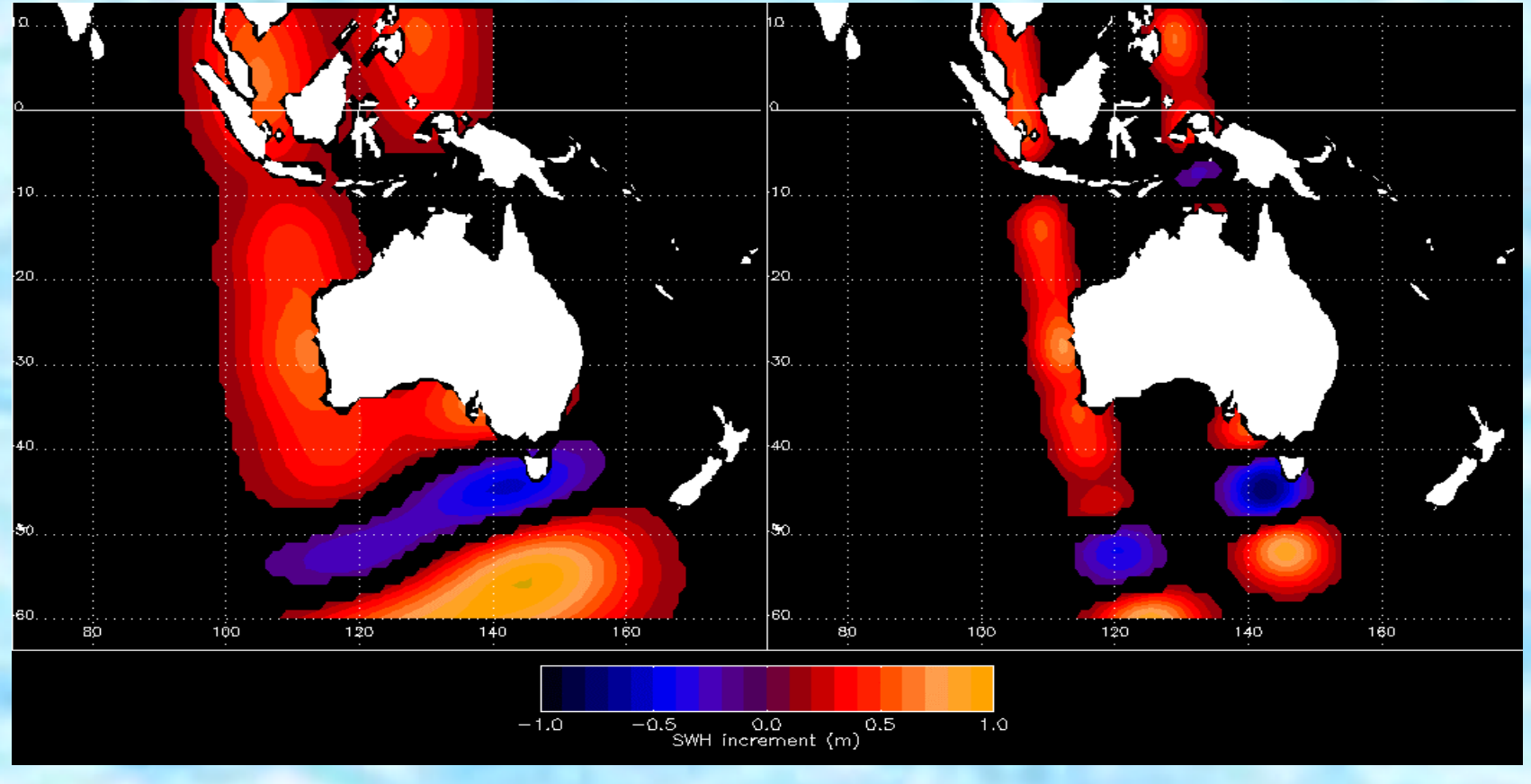

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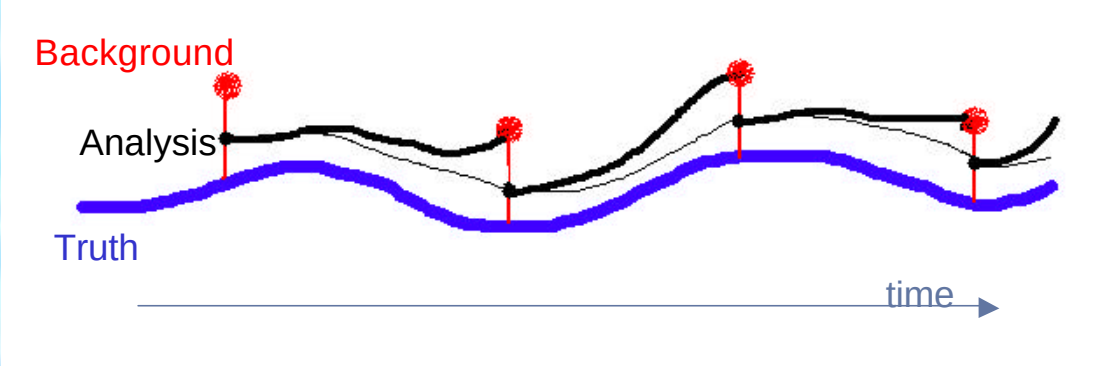
Method

- Want to know spatial scale of background errors in wave model
- 'NMC method'
  - "National Meteorological Center"
  - Look at differences between forecasts of SWH at different ranges valid at same time e.g. 48-hour vs. 24-hour
  - How much and on what spatial scales the error grows within 24-hours
    - Perfect wind forcing, perfect wave model:
      - 48-hour forecast and 24-hour forecast valid at the same time would be identical.
    - Perfect wind forcing, imperfect wave model
      - Wave forecasts still identical
  - Differences between the two are due to errors in wind forecasts and how the wave model propagates those errors.

Method (cont.)

- Issues:
  - Forecast divergence = background error?



  - Background error = analysis error + forecast error
  - Forecast divergence doesn't give whole picture
  - Can still get useful information

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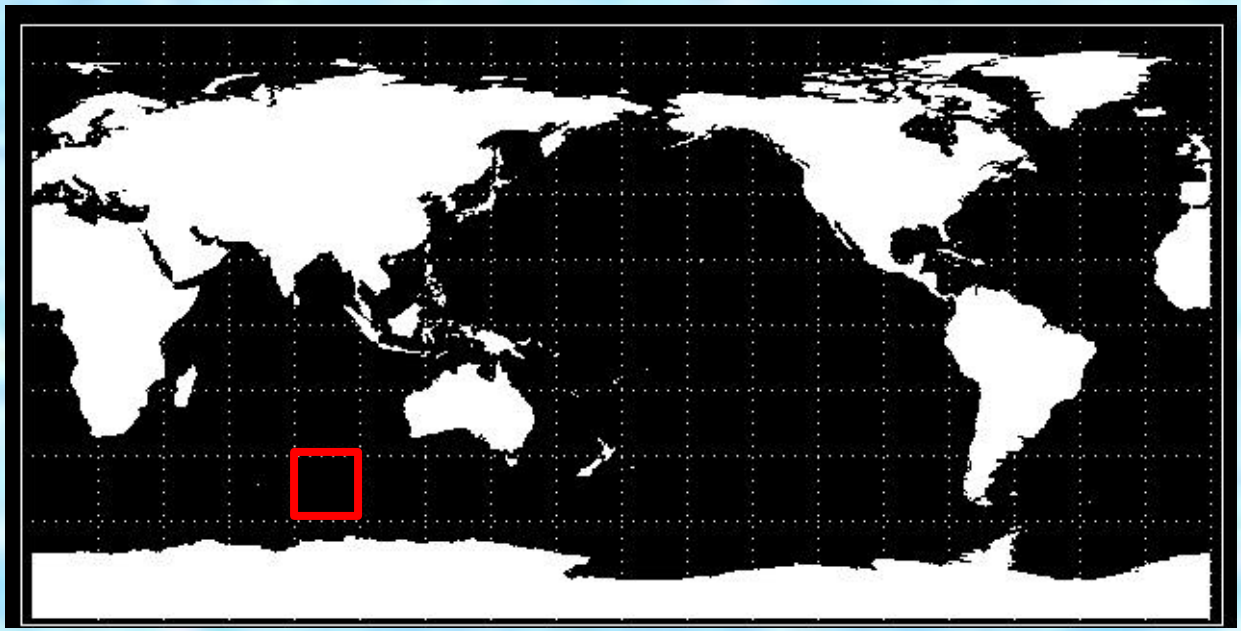

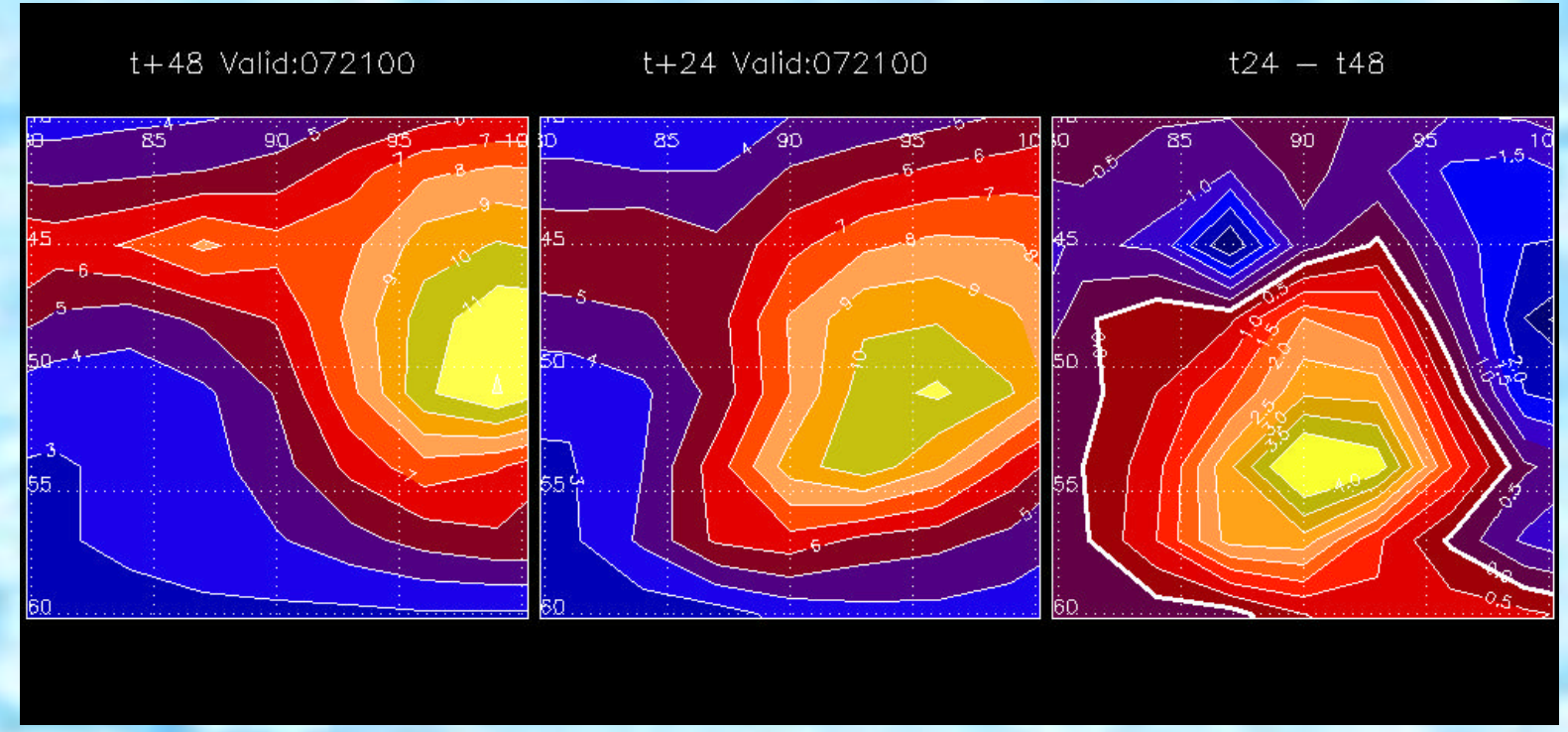

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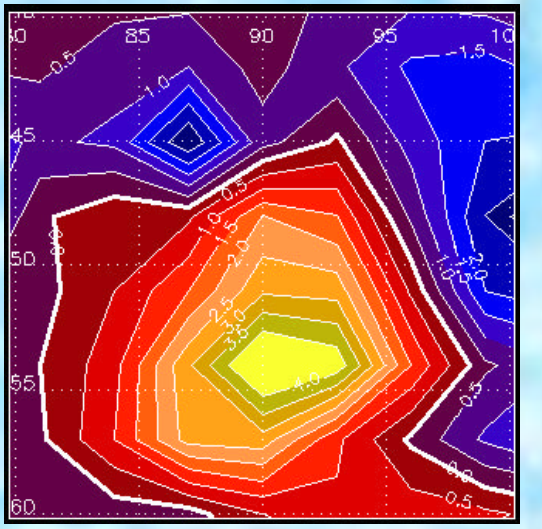
Method (cont.)

- Collect 3 months of t48 - t24 SWH differences at 12-hour intervals
- Calculate spatial correlations:

$$r(r,q) = \frac{\overline{\left(\mathrm{t48}_j - \mathrm{t24}_j\right)\left(\mathrm{t48}_k - \mathrm{t24}_k\right)}}{\sqrt{\overline{\left(\mathrm{t48}_j - \mathrm{t24}_j\right)^2}\ \overline{\left(\mathrm{t48}_k - \mathrm{t24}_k\right)^2}}}$$

- $r = \mathrm{dist} \quad j \to k$

  $q = \mathrm{angle} \quad j \to k$



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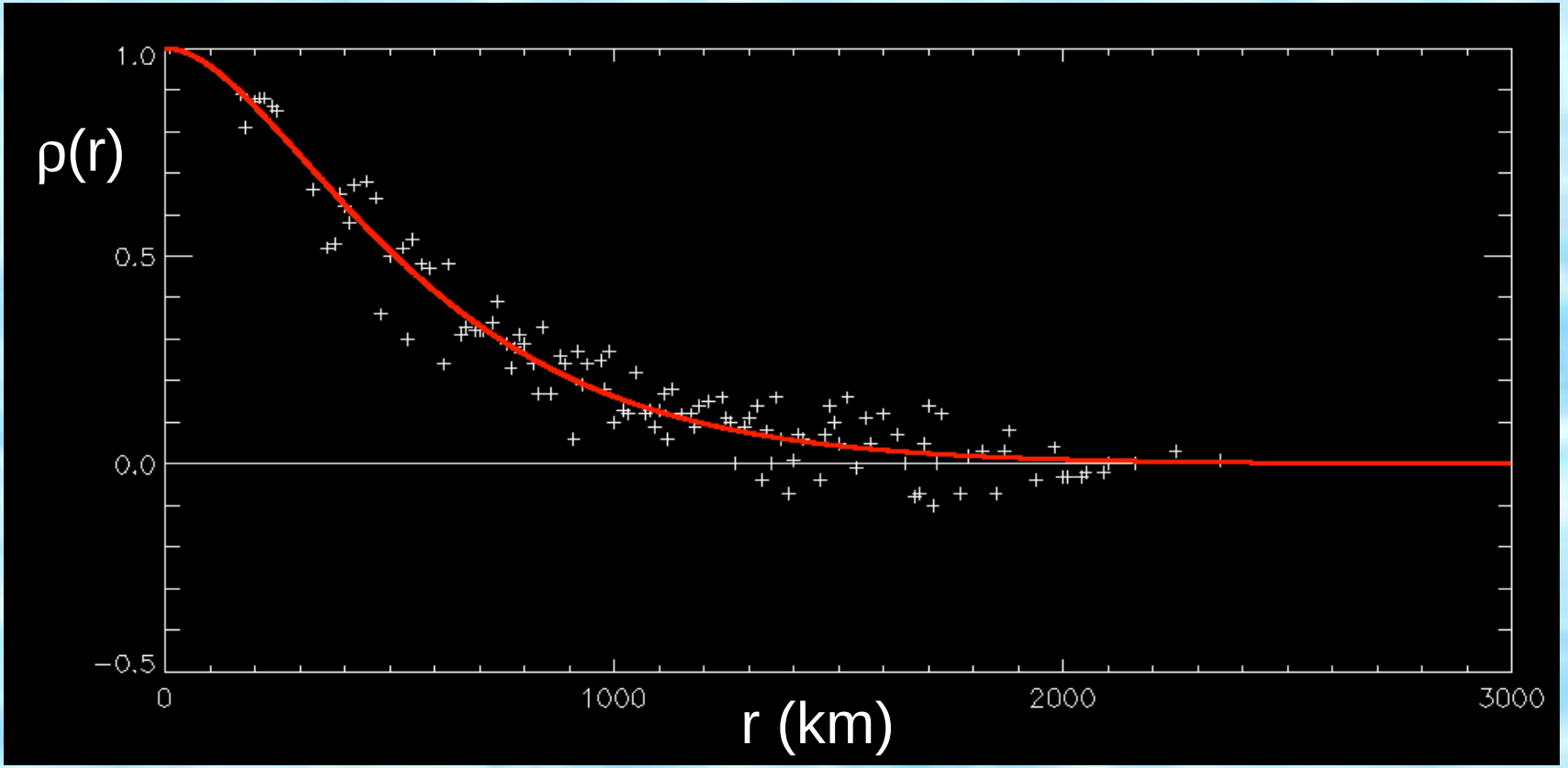
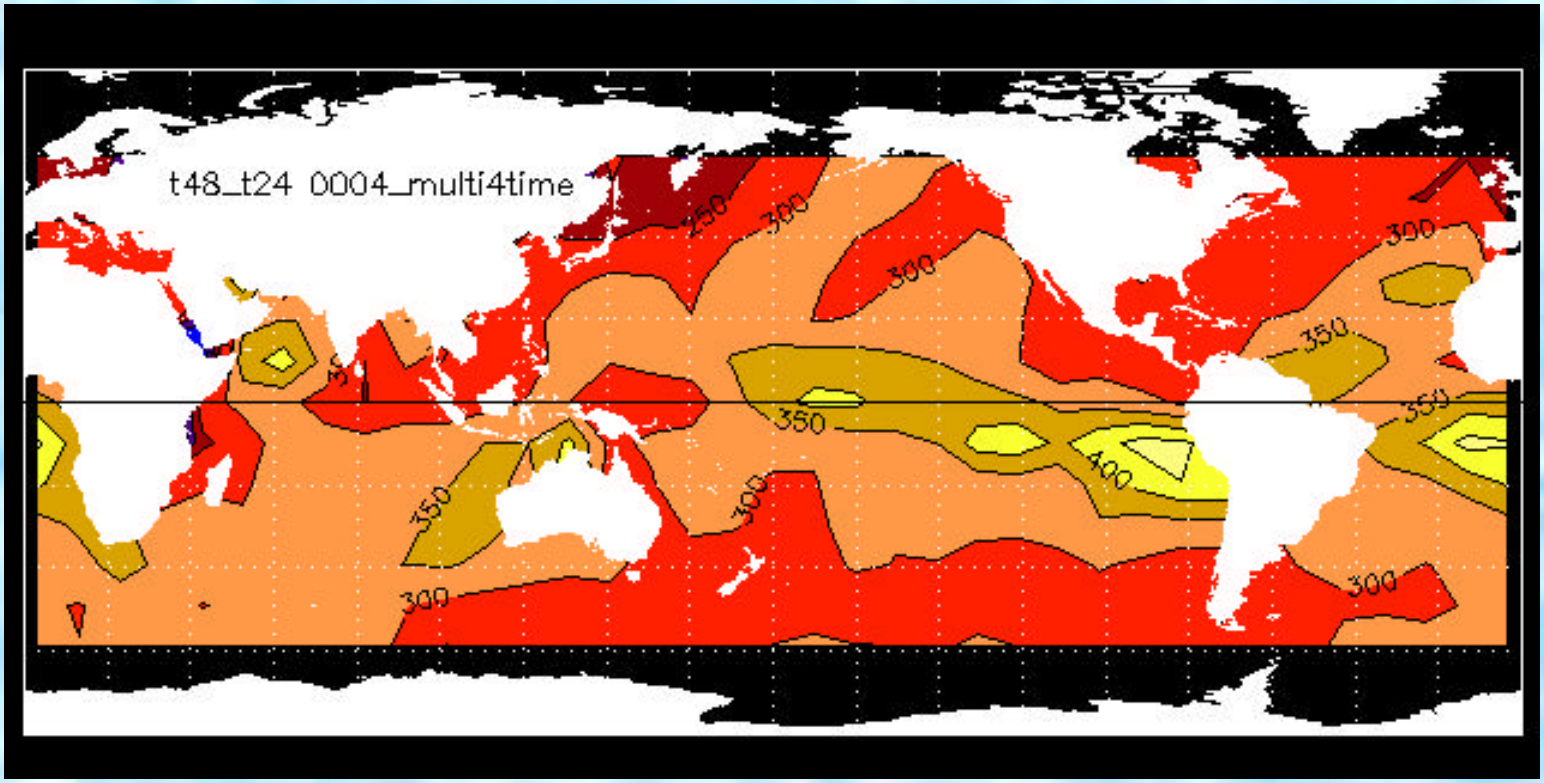
Isotropic correlations



$$r(r) = \left(1 + \frac{r}{L}\right)\exp\left[-\frac{r}{L}\right]$$

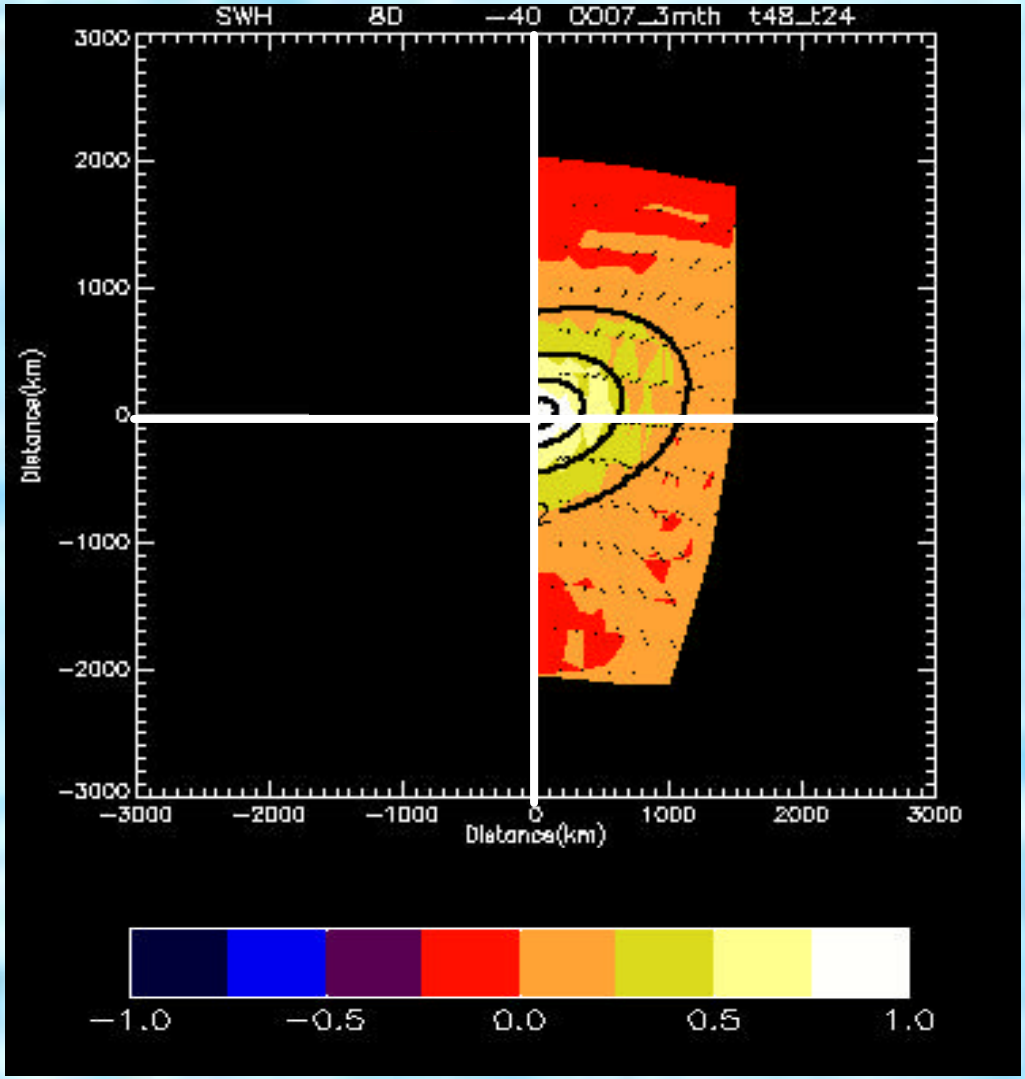
L = 306 km
= correlation scale

Annual average correlation scale



[Operational Bureau system: 200km globally]

Anisotropic correlations



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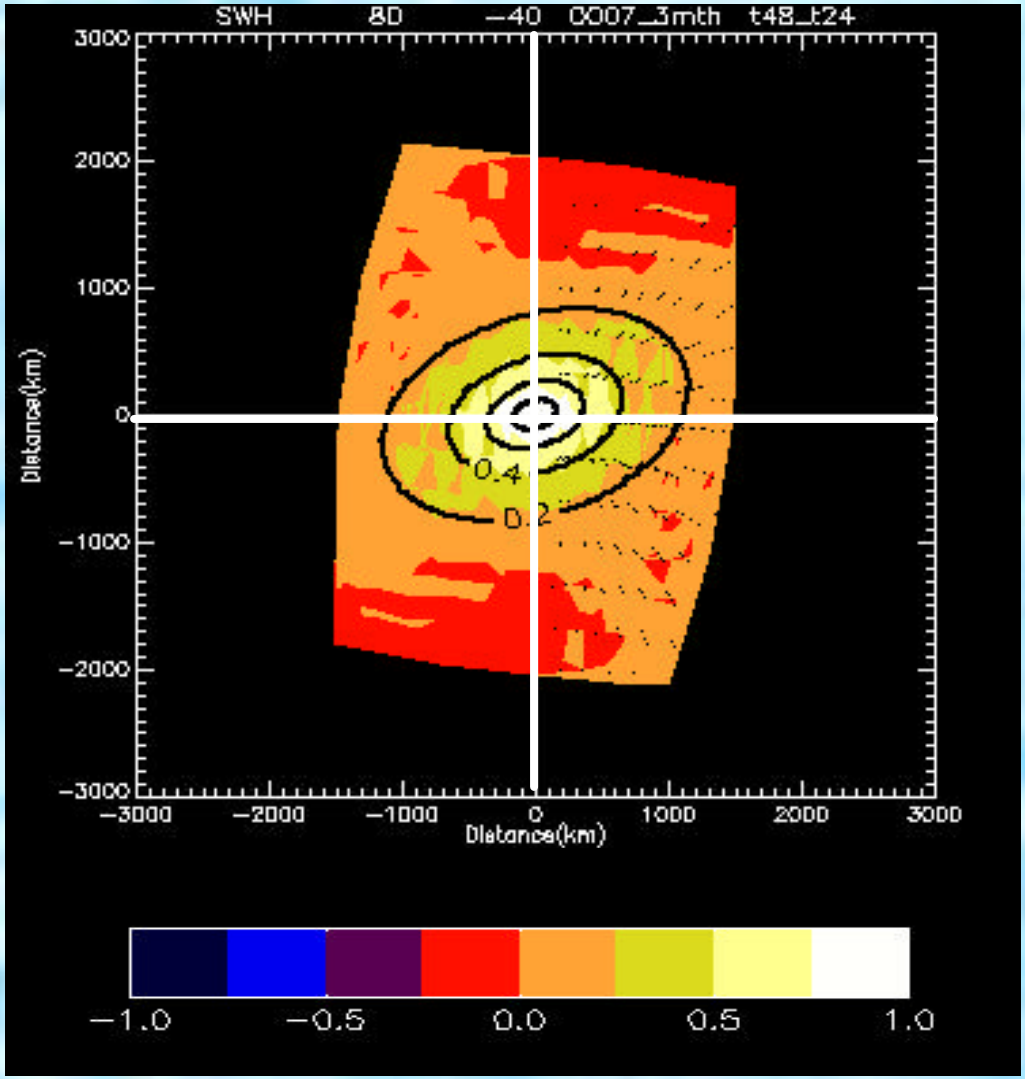
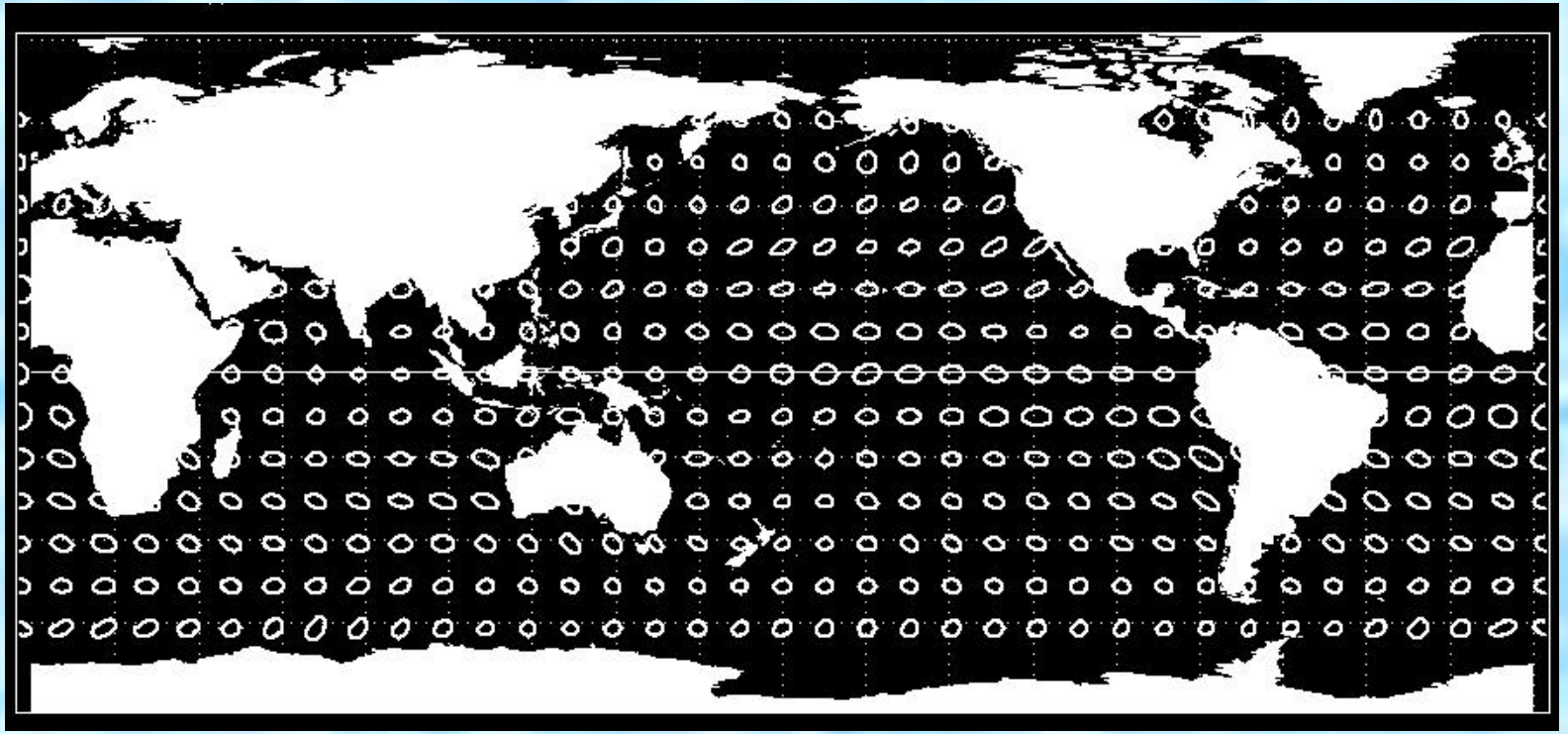
Anisotropic correlations



3 variable parameters

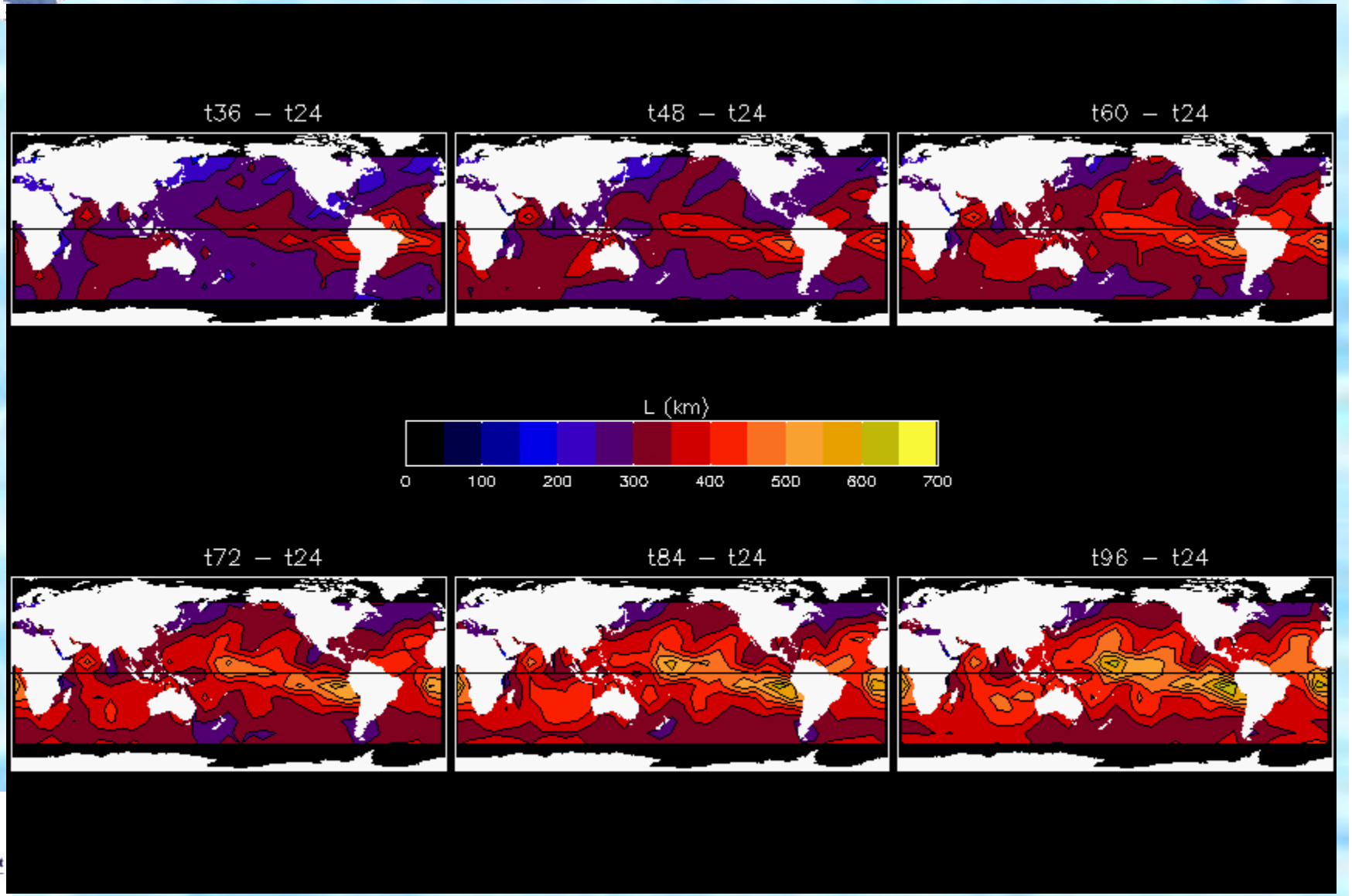
- eccentricity
- tilt
- length scale

Annual average



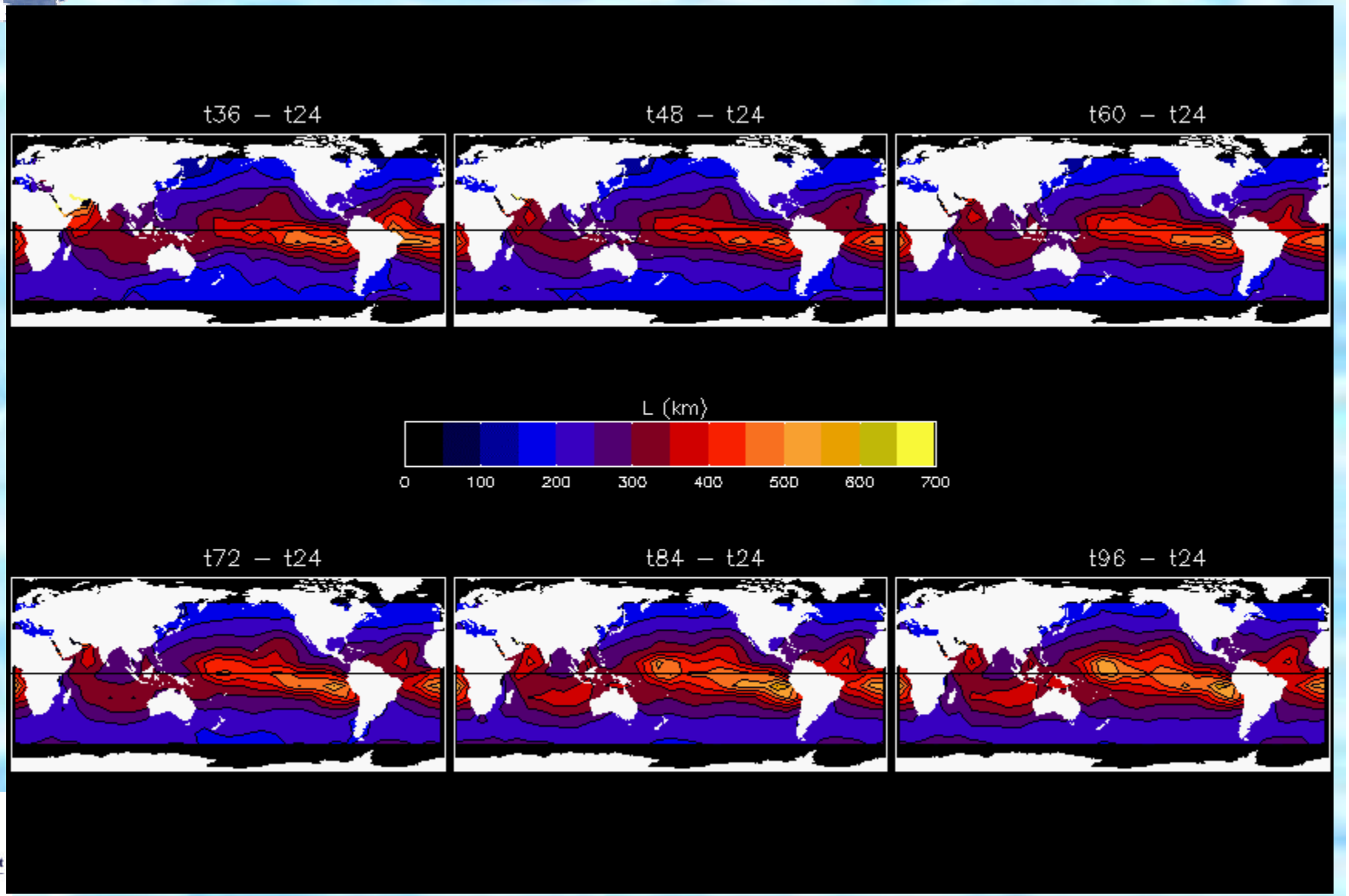
[Operational Bureau system: isotropic]

Forecast period
Isotropic: SWH



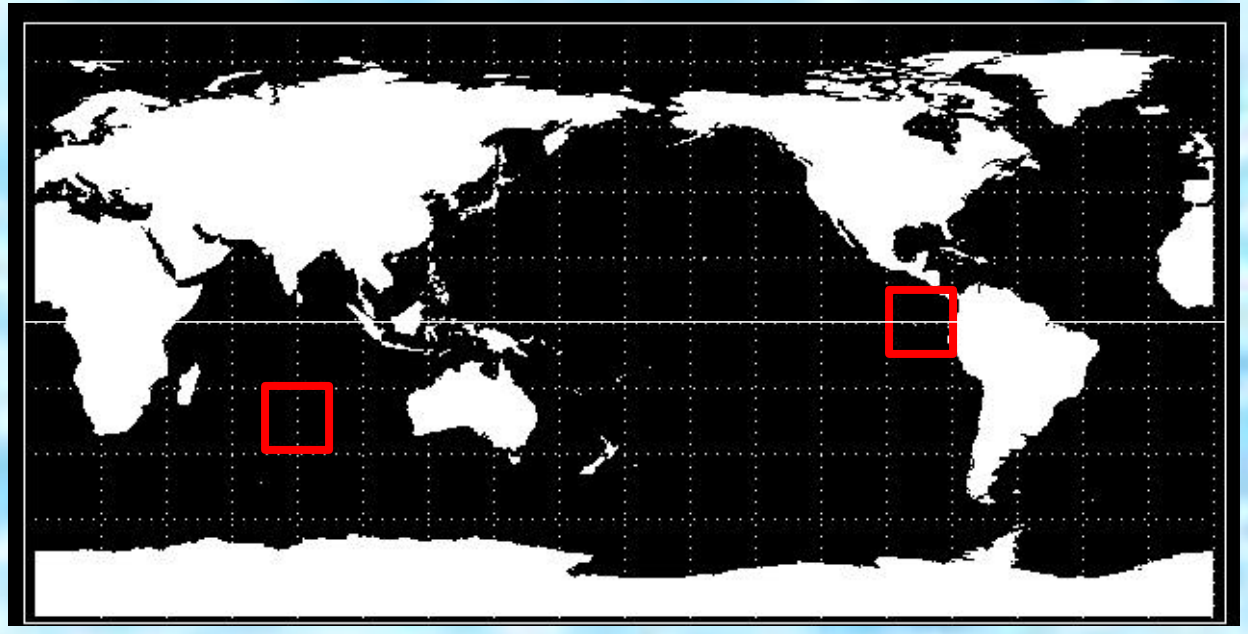
Forecast period

Isotropic: u_{10}



Forecast period

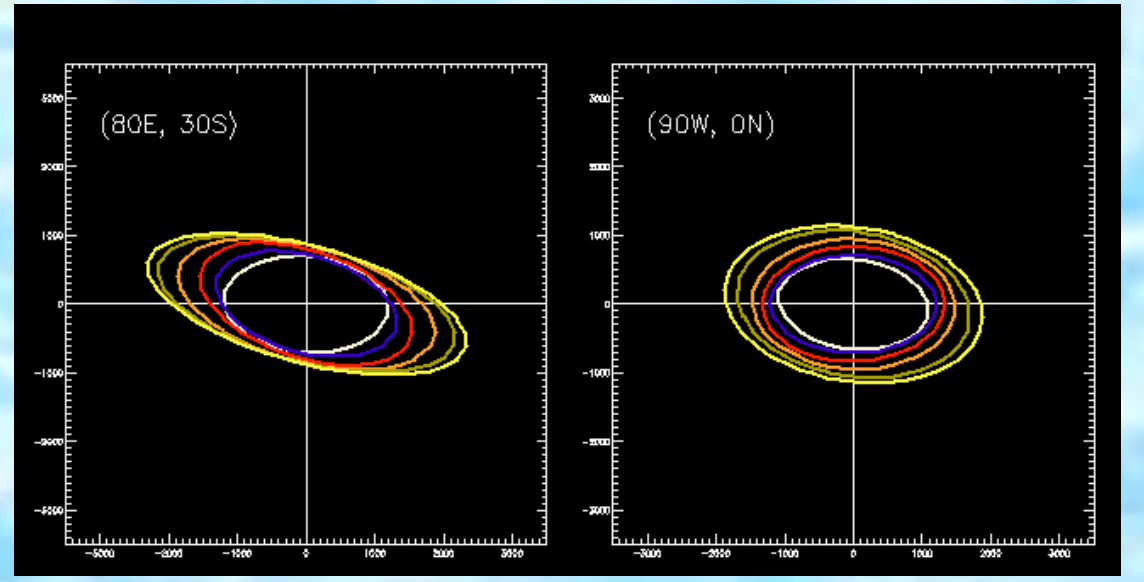
Anisotropic

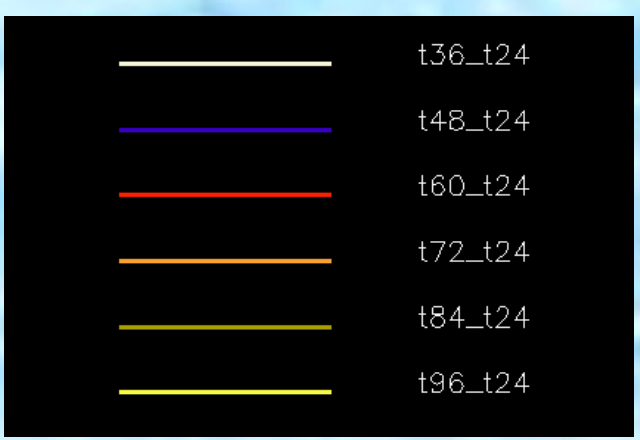


Annual average

Indian

Pacific





Indian Ocean

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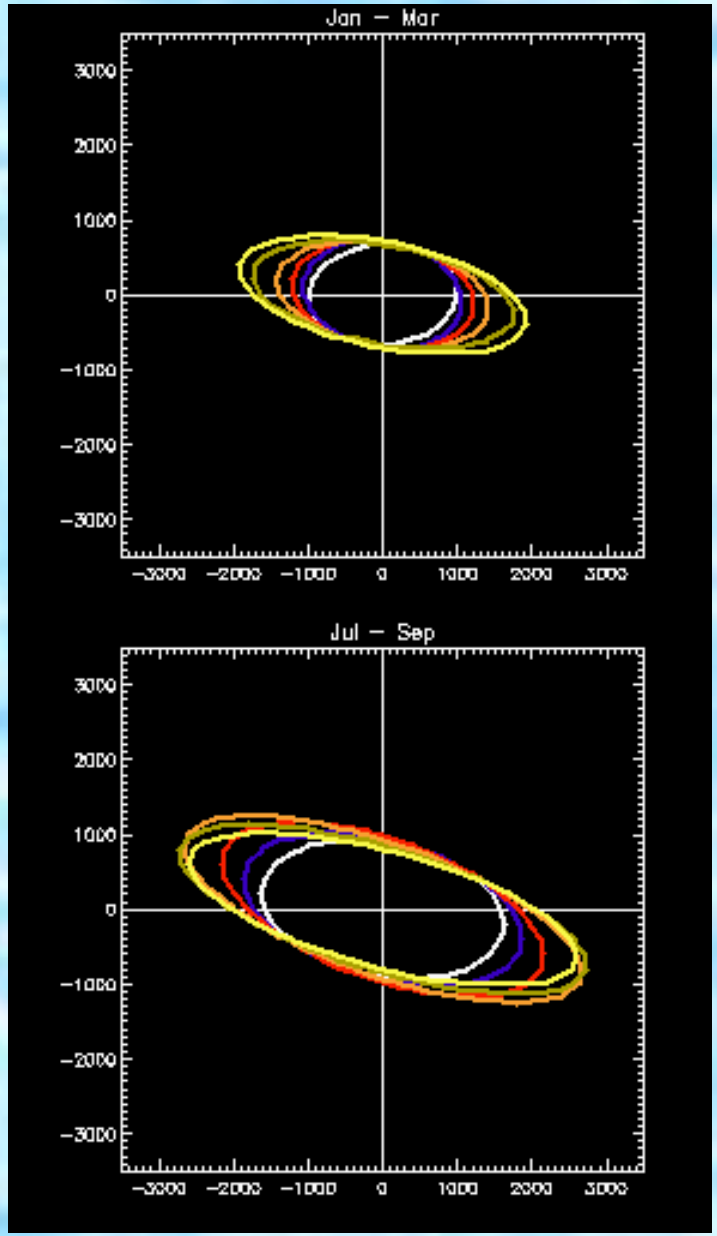

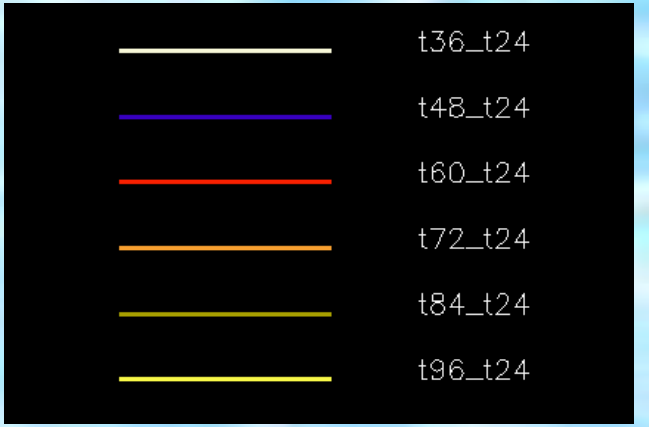

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Pacific Ocean

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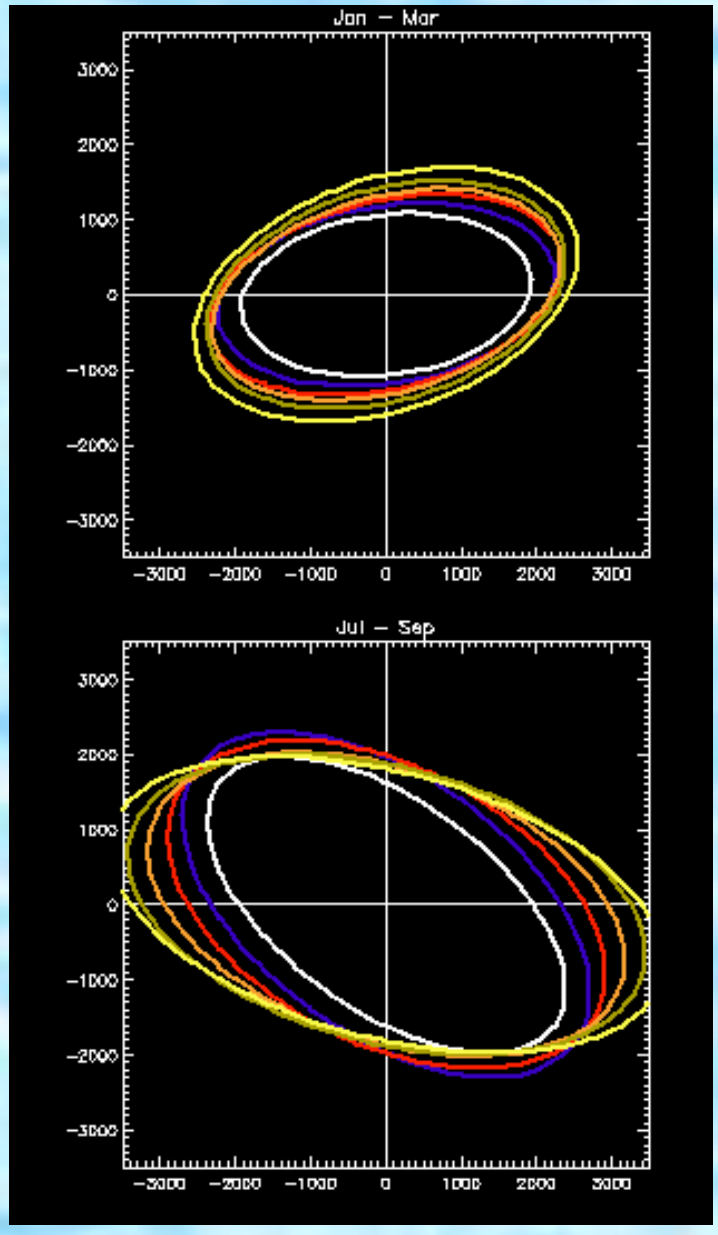

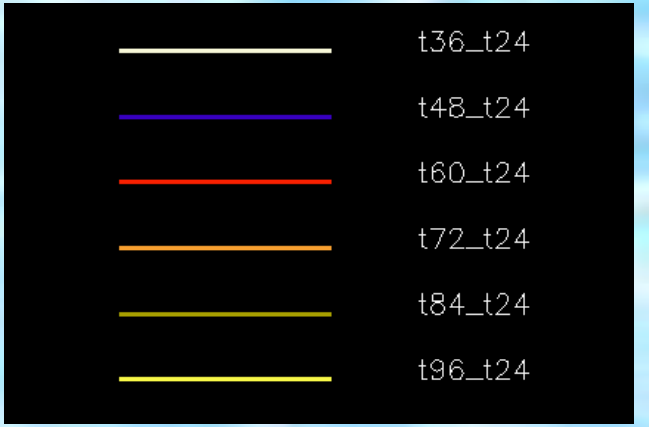

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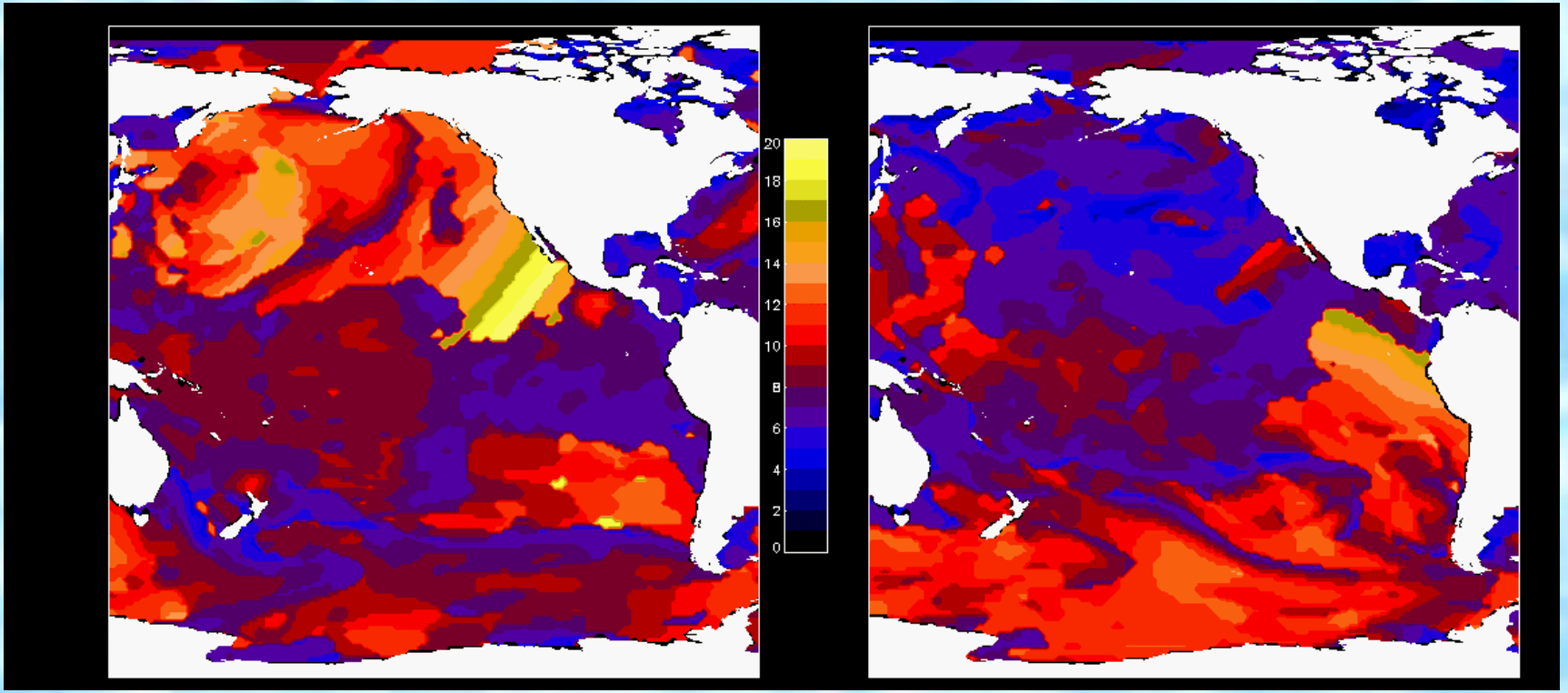
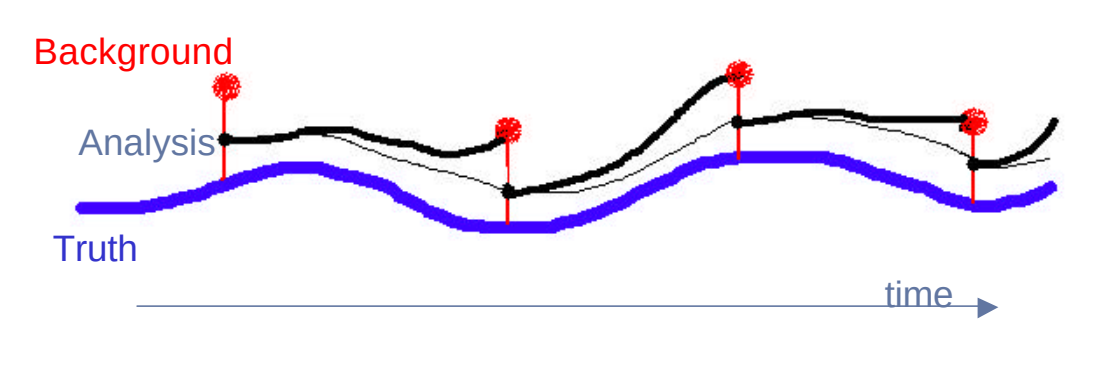
Peak Period (sec)



January **June**

Issues

- Relevance to data assimilation



- NMC method:
  - Divergence of forecasts
  - No analysis error
  - Lower bound to background error
- Typically, operational wave data assimilation systems use homogenous, isotropic spatial scales for background error
  - Background errors vary over globe
  - Forecast divergence component: anisotropic and seasonal in places
- Potential to improve data assimilation schemes

Summary

- Data assimilation systems need to know the spatial scale of background error
- The NMC method considers forecast divergence component of background error
- Spatial scale varies over globe with longest scales near equator.
- Spatial scale increases with forecast period
  - Due to swell errors propagating and dispersing
  - Swell errors are anisotropic and seasonal
- Potential to improve data assimilation systems