University of Cantabria
IH-Cantabria
http://www.ihcantabria.com

Marine Climate and Climate Change Group

A method to evaluate the generation area of local wave climate

Jorge Pérez (perezgj@unican.es)
Fernando J. Méndez (mendezf@unican.es)
Melisa Menéndez (menendezm@unican.es)

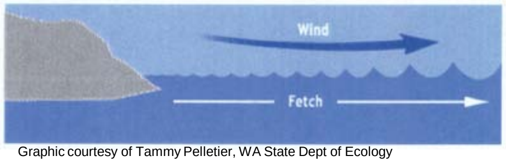
European Geosciences Union
General Assembly 2013
Vienna | Austria | 07 – 12 April 2013

Outline:

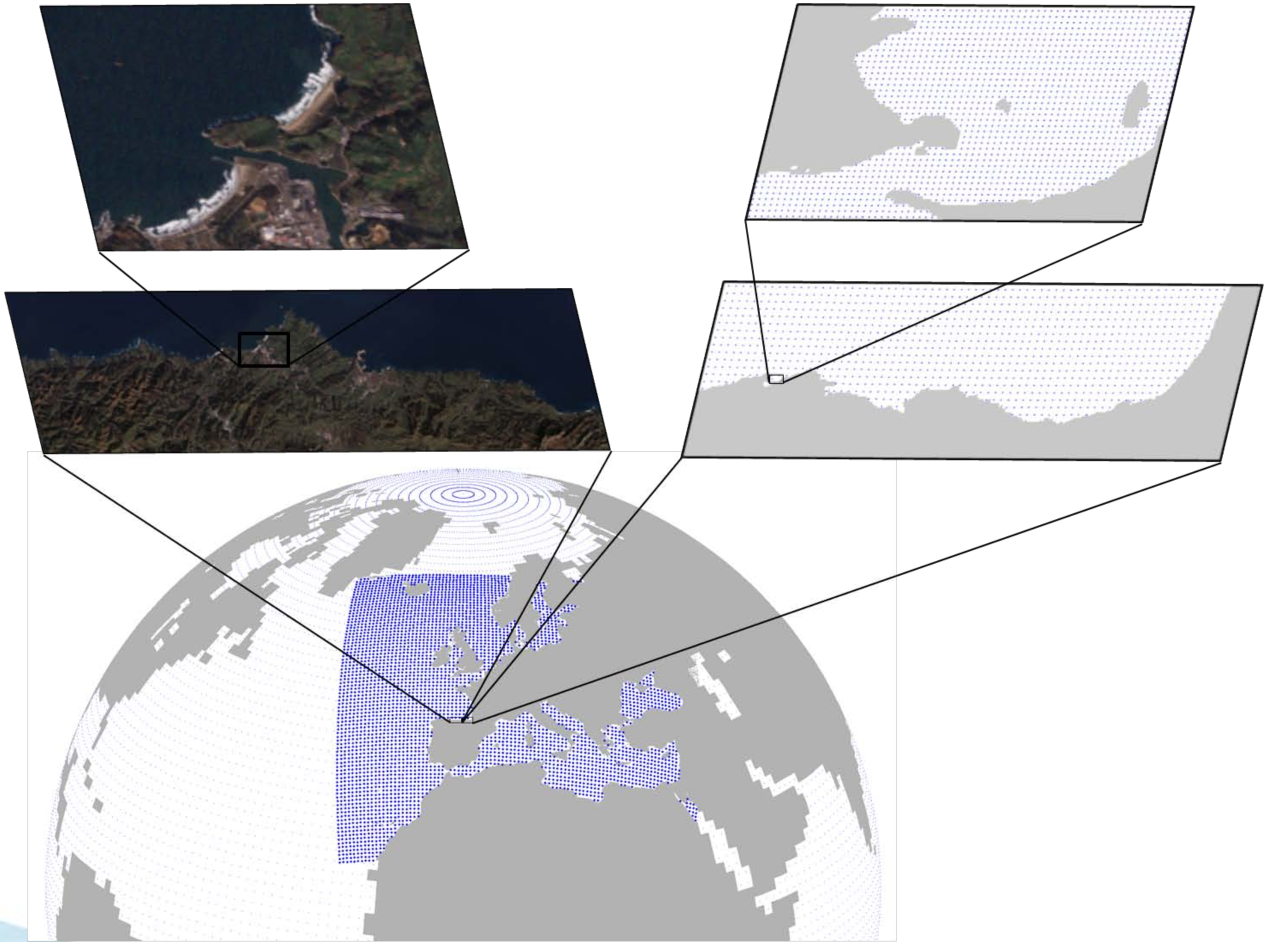
1. Introduction
2. Data
3. Method
   - Geographical criterion
   - Physically-based criterion
4. Results
5. Conclusions

MOTIVATION: Why we need to **evaluate the generation area of local wave climate**?

Useful for downscaling, storm tracking…, but result of dynamics over an area of influence

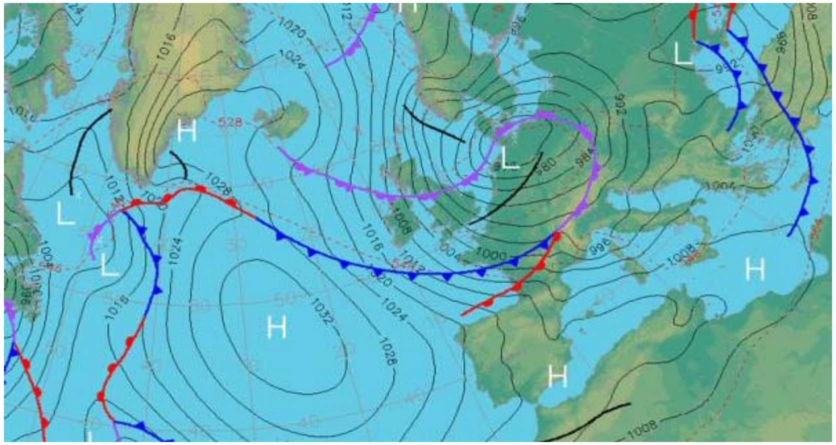


Graphic courtesy of Tammy Pelletier, WA State Dept of Ecology



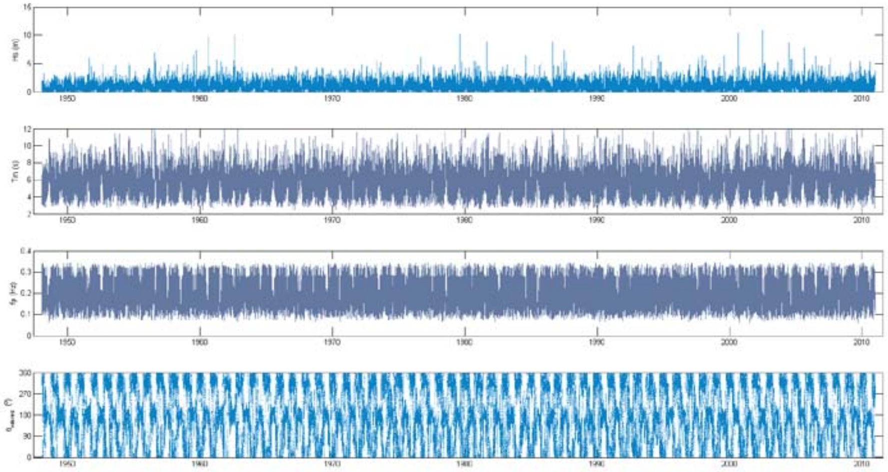
STATISTICAL DOWNSCALING

Large scale predictors (X)



Y=f(X)

Local predictands (Y)



It is based on atmospheric circulation dynamics (**difficult in not well known areas**)

PROBLEMS: According to expert criteria (**subjective**)

Requires many tests (**waste of time**)

MAIN GOAL

*Determination of the spatial domain of influence **for any particular location** in the world to **automate the definition of the predictor area** for statistical downscaling*

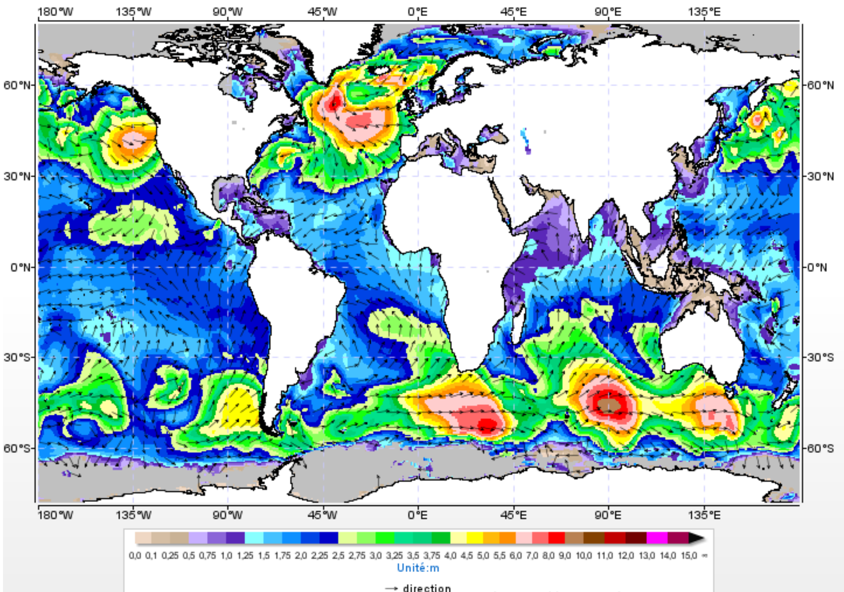
DATA: Global wave reanalysis (Rascle and Ardhuin, 2012)

WaveWatch III v4.04 forced by CFSR winds

Spatial coverage: Global (0.5ºx0.5º)

Spectral grid: 24 directions, 37 frequencies

Temporal coverage: 1994-2007 (3hourly)



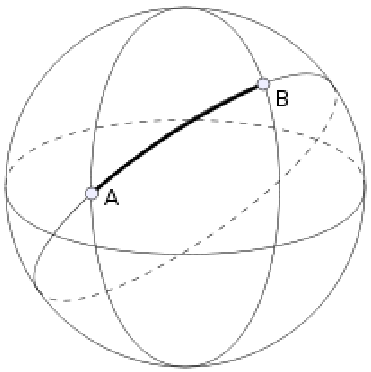
http://wwz.ifremer.fr

OUTPUTS:

- Significant wave height
- **Mean period Tm0,-1**
- **Mean direction (full spectrum)**
- **Directional spread (full spectrum)**
- Hs for wind sea
- Hs for the first swell
- **Wave energy flux**
- Mean period Tm02
- rms of bottom amplitude displacement
- rms of bottom velocity amplitudes
- radiation stresses (depth-integrated)
- waves-> ocean momentum flux
- wave-induced Bernoulli head pressure
- Stokes transport (depth integrated Stokes drift)
- Surface Stokes drift
- Surface Stokes drift spectrum
- air-side friction velocity
- wind → waves energy flux
- waves → ocean TKE flux
- height of breaking waves
- wind → waves momentum flux
- Charnock parameter (air)
- Mean square slopes
- Phillips constant
- Spectra density P2(k)
- log of spectral density P2(f,k)

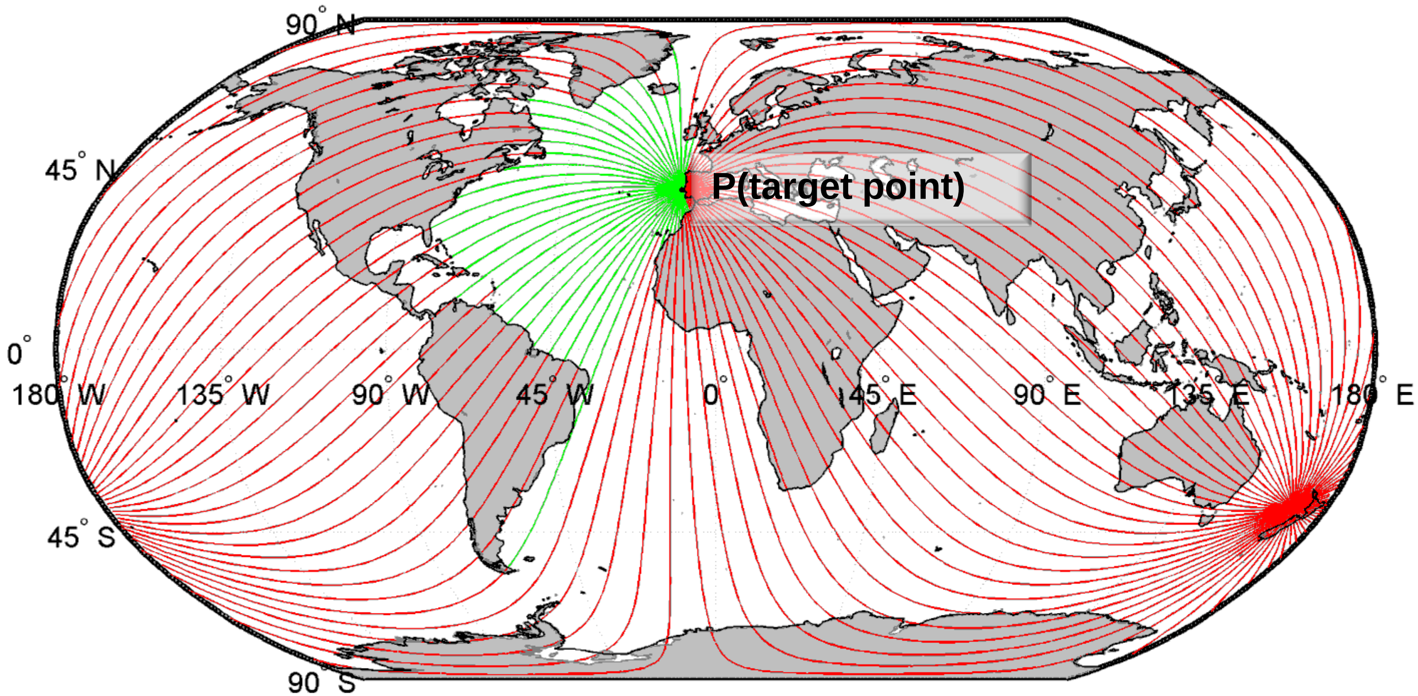
METHOD: Energy flux analisys (2 steps)

1- Geographical criterion



Waves move away

along great circle paths



Grid points related to the reference point by a great

circle that cross the coast are eliminated.

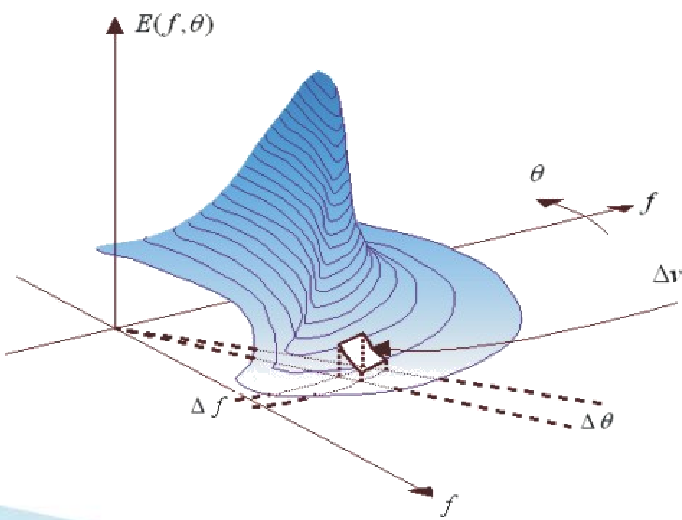
METHOD: Energy flux analisys (2 steps)

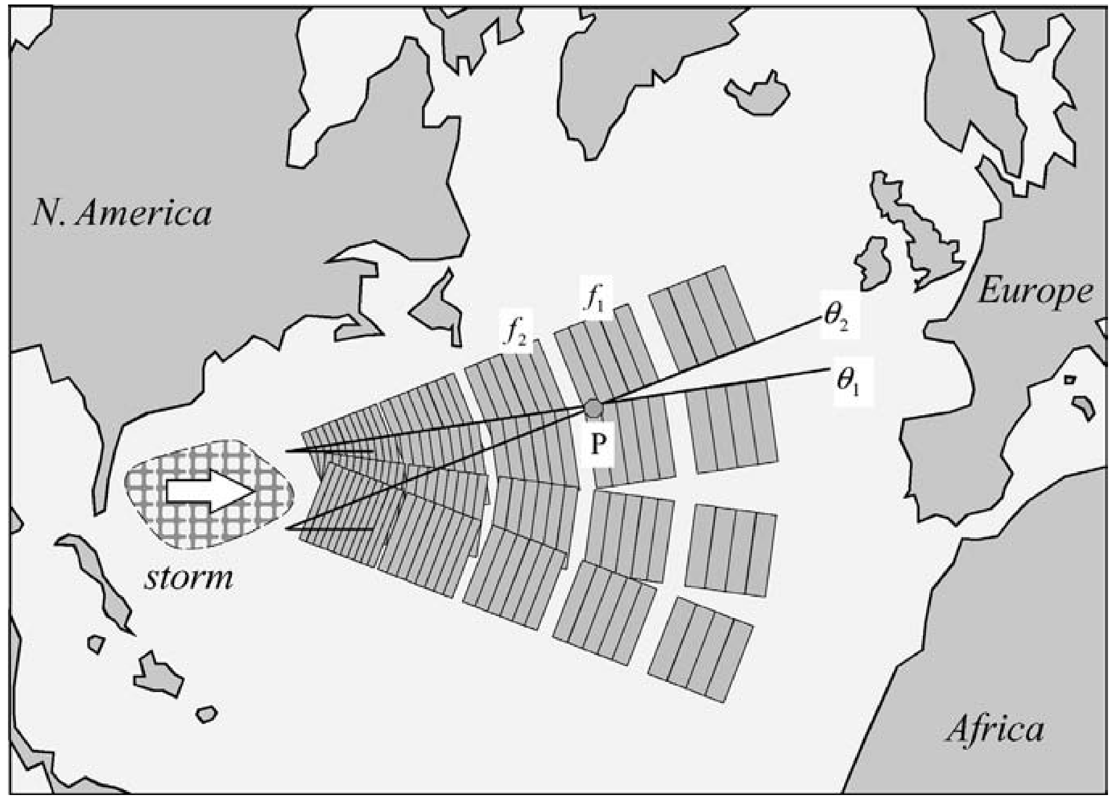
2- Physically-based criterion

2.1 Spectrum reconstruction

2.2 Example node

2.3 Spatial representation





Holthuijsen (2007)

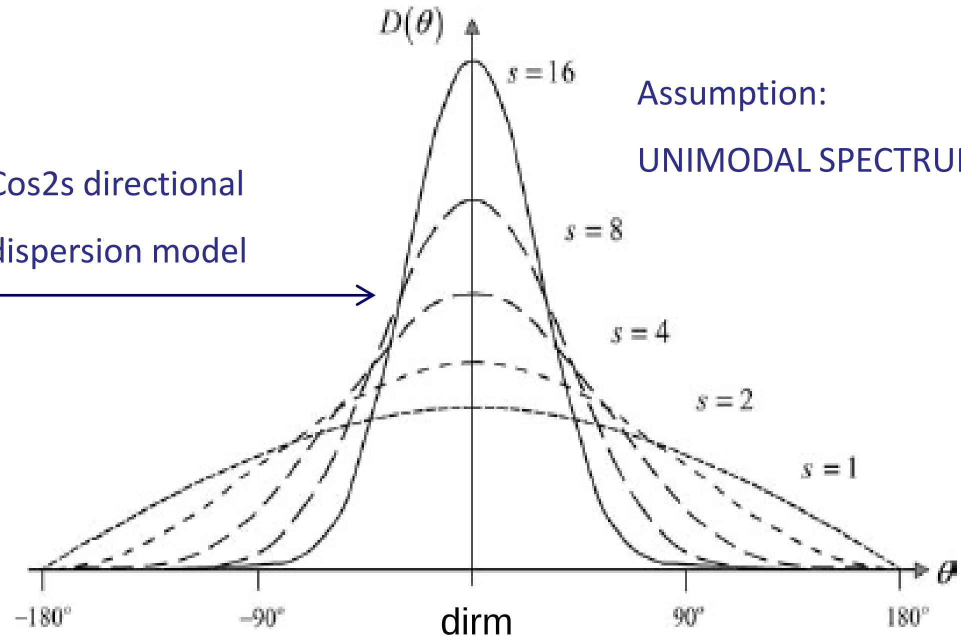
Only the energy travelling between θ_1 and θ_2 reaches the target point P

Spectrum reconstruction

Wave parameters:

- wave energy flux
- mean direction (dirm)
- directional spread (σ)

Cos2s directional dispersion model



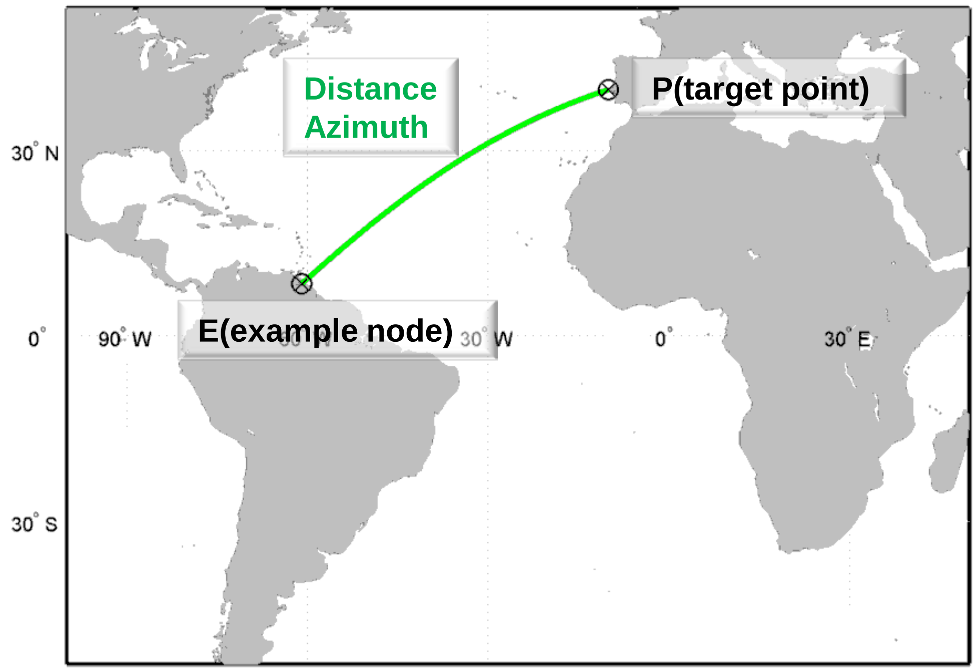
The cos2s(1/2θ) model for the directional energy distribution under idealised conditions. Holthuijsen (2007)

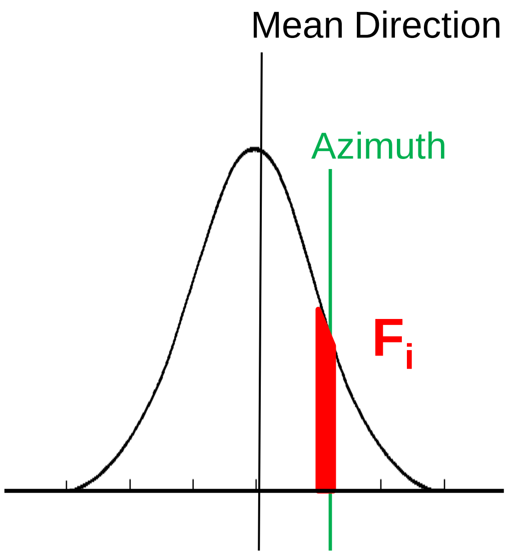
Assumption:

UNIMODAL SPECTRUM

- mean energetic period (Tm0-1) → group celerity (C_g)

Example node





The azimuth is the angle formed between North and a line from the example node to the target point

Valid energy flux for a sea state i (F_i) depends on the difference between the mean wave direction and the azimuth.

Average over a temporal serie of N sea states:

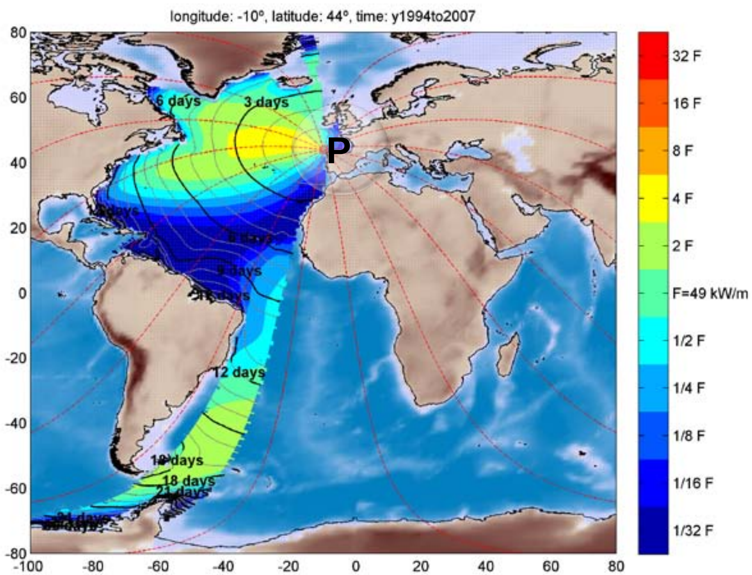
$$\bar{F} = \frac{\sum_{i=1}^{N} F_i}{N}$$

Effective energy flux ($\bar{F}$)

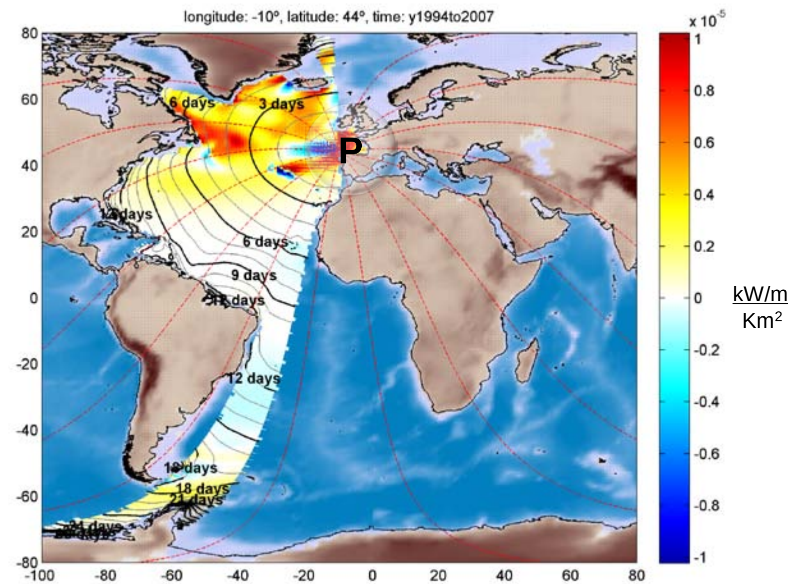
$$\bar{T} = \frac{Distance}{\sum_{i=1}^{N} F_i Cg_i \Big/ \sum_{i=1}^{N} F_i}$$

Travel time ($\bar{T}$)

Spatial representation



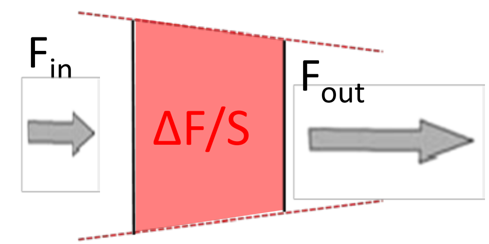
*A) **Energetic areas** referred to target point (P)*



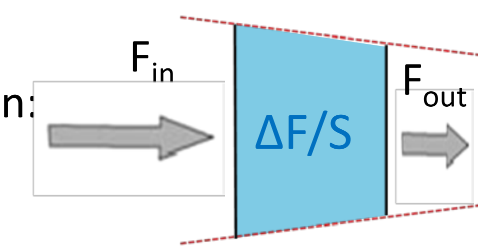
*B) **Generation/Dissipation areas** referred to target point (P)*

Energy traveling towards the target point(respect to mean energy flux in the target point) and isolines for travel time (in days).

Generation:
($F_{out} > F_{in}$)

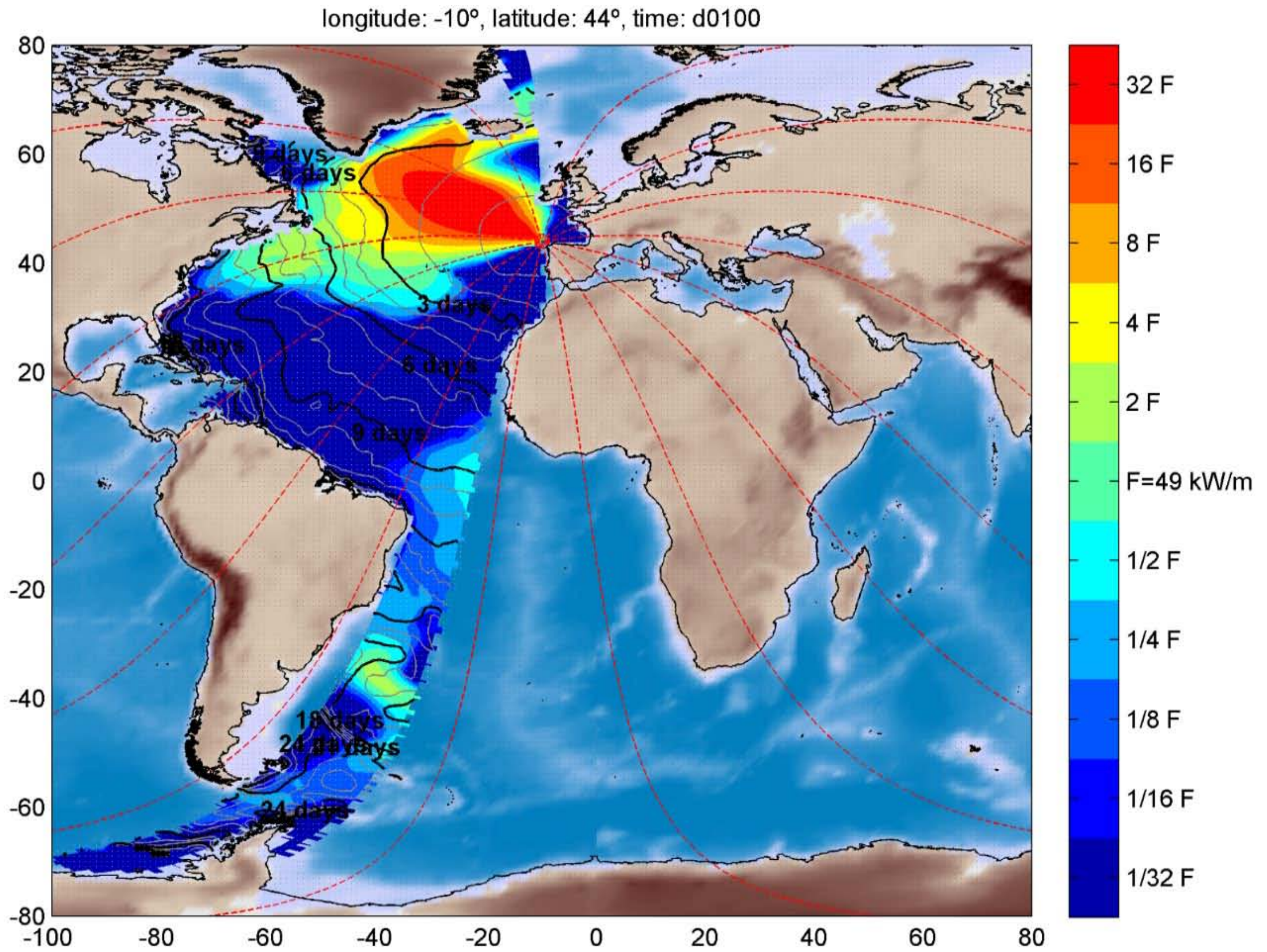


Dissipation:
($F_{out} < F_{in}$)



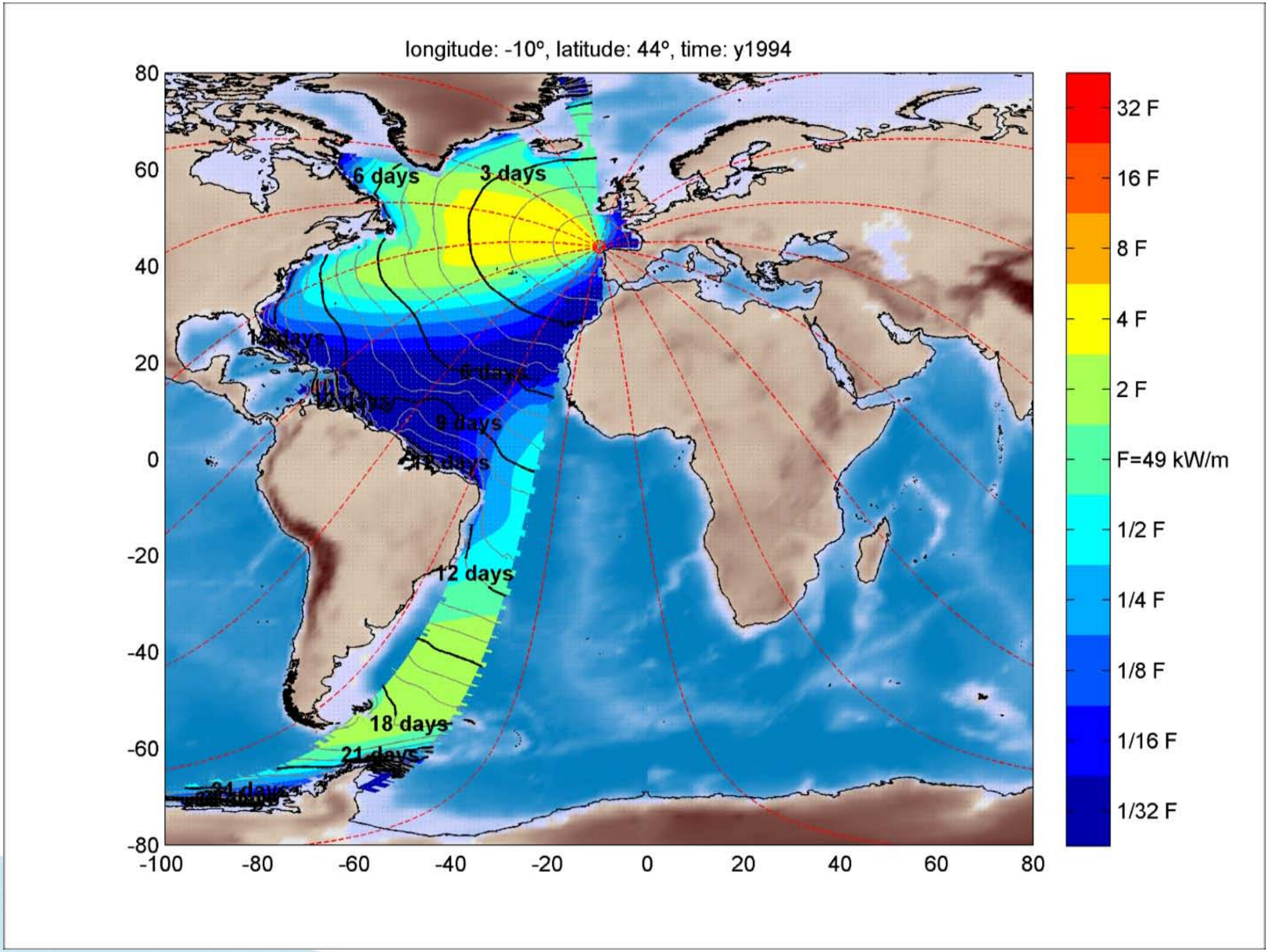
RESULTS: A CORUÑA, DECEMBER 2007

A Coruña (Spain)



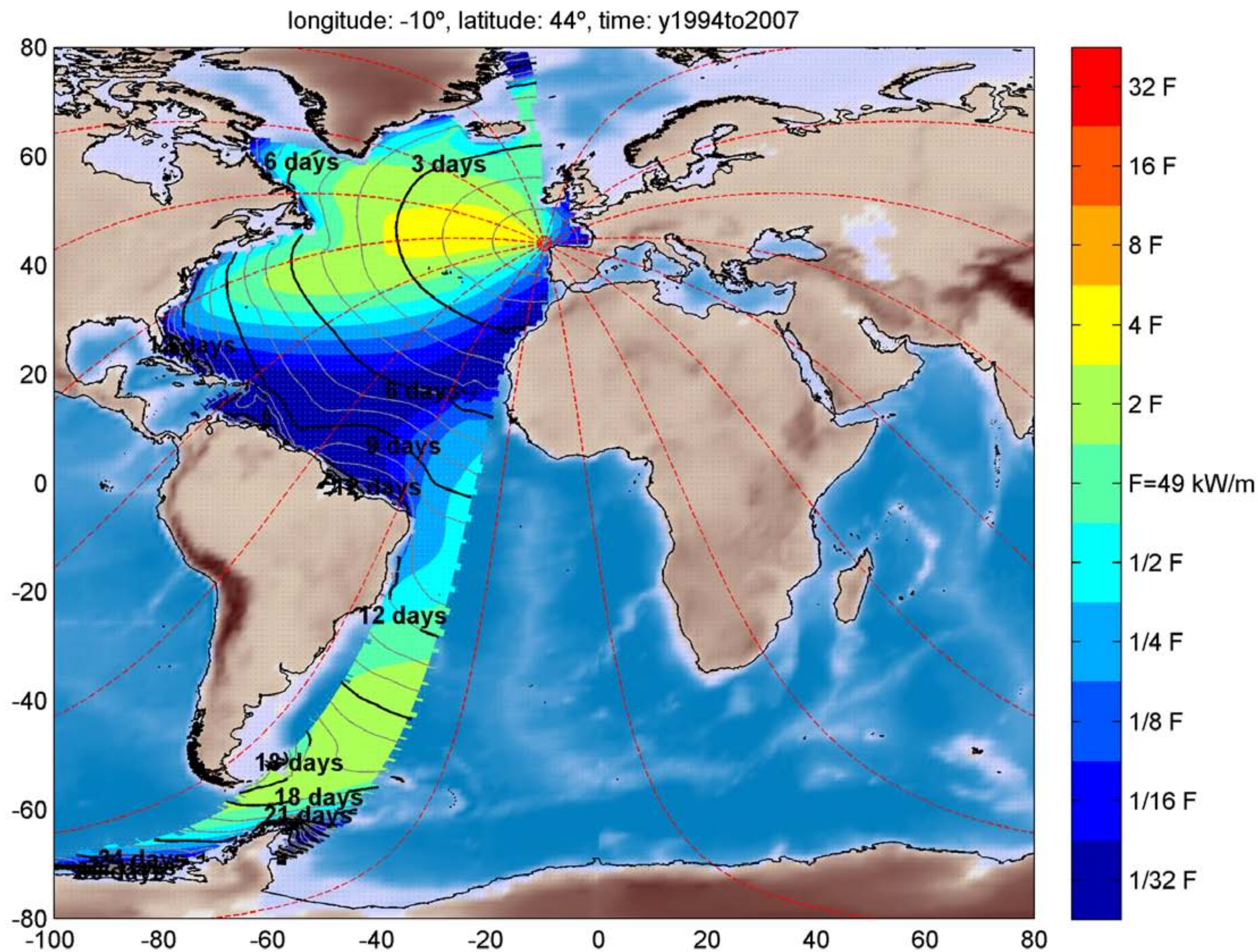
RESULTS: A CORUÑA, INTERANNUAL VARIABILITY

A Coruña (Spain)



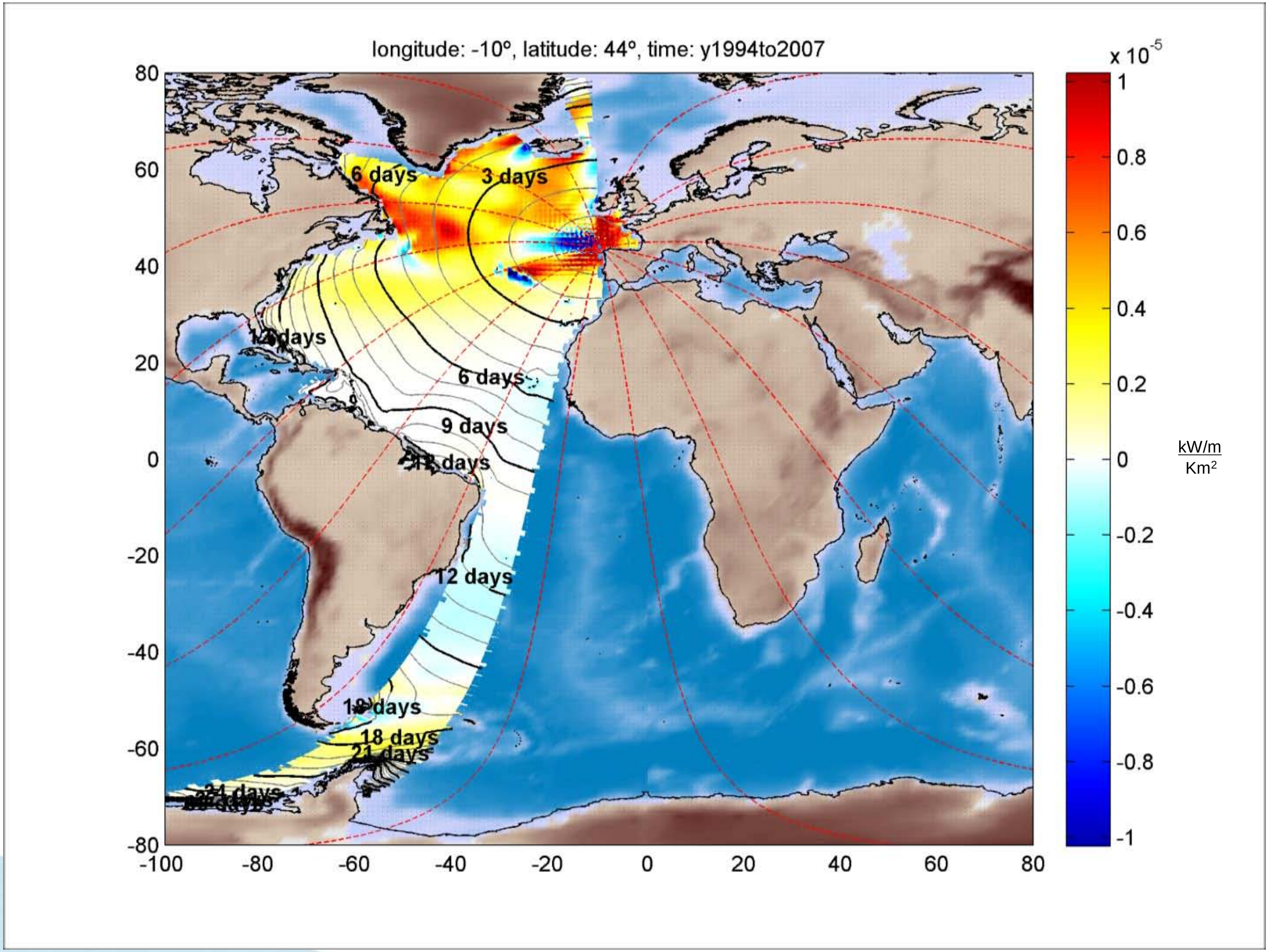
RESULTS: A CORUÑA, 1994-2007

A Coruña (Spain)



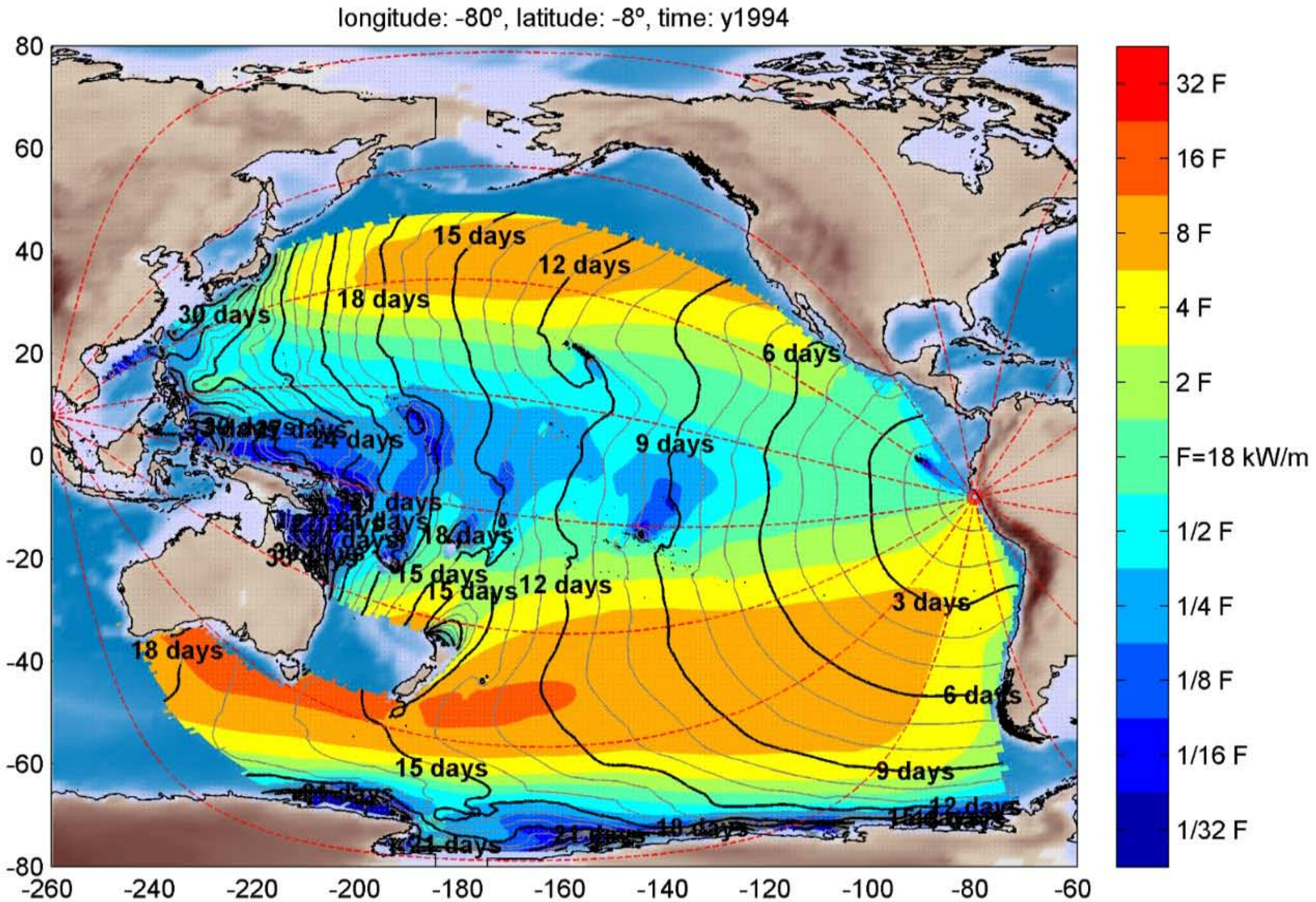
RESULTS: A CORUÑA, 1994-2007

A Coruña (Spain)



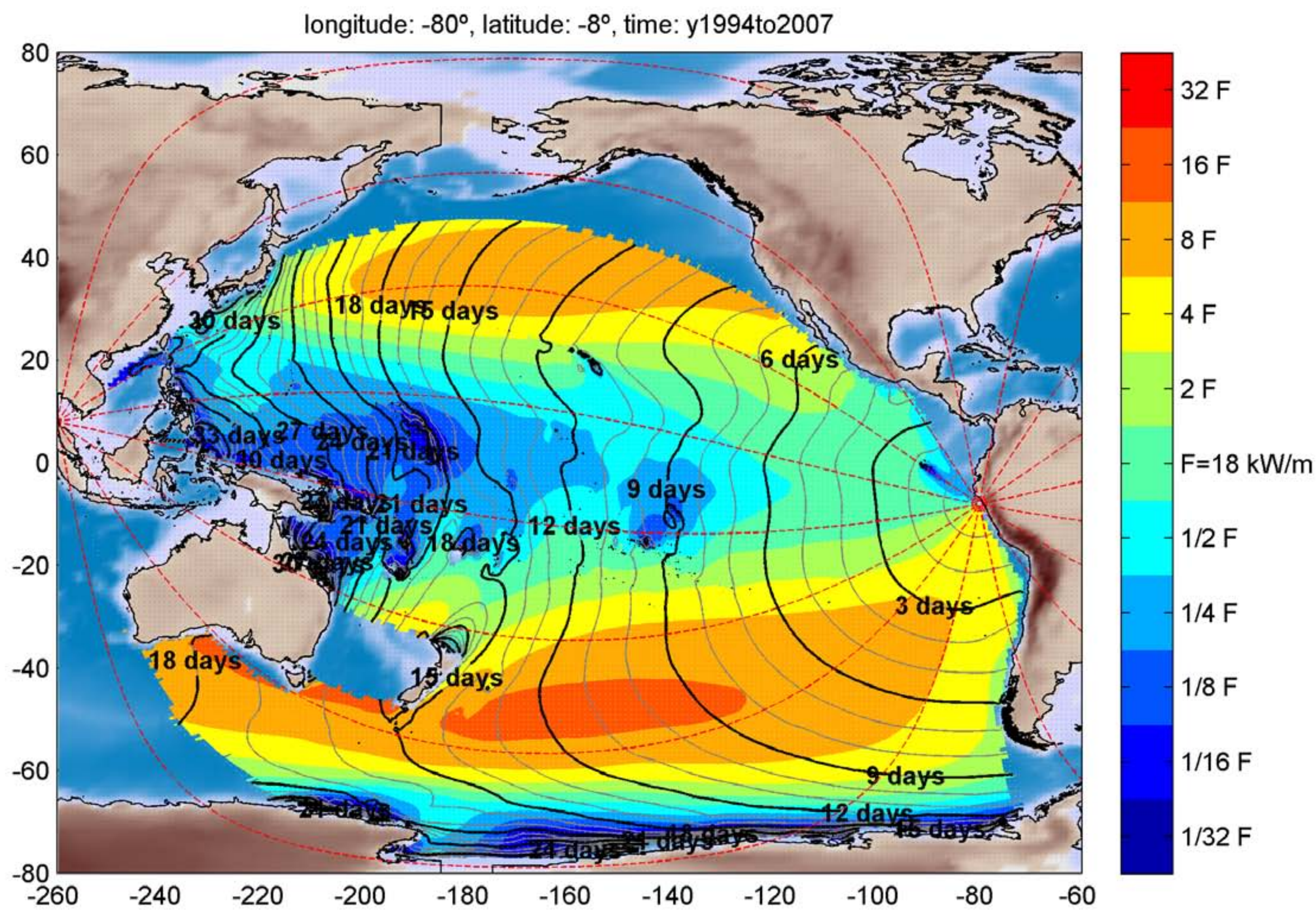
RESULTS: TRUJILLO , INTERANNUAL VARIABILITY

Trujillo (Peru)



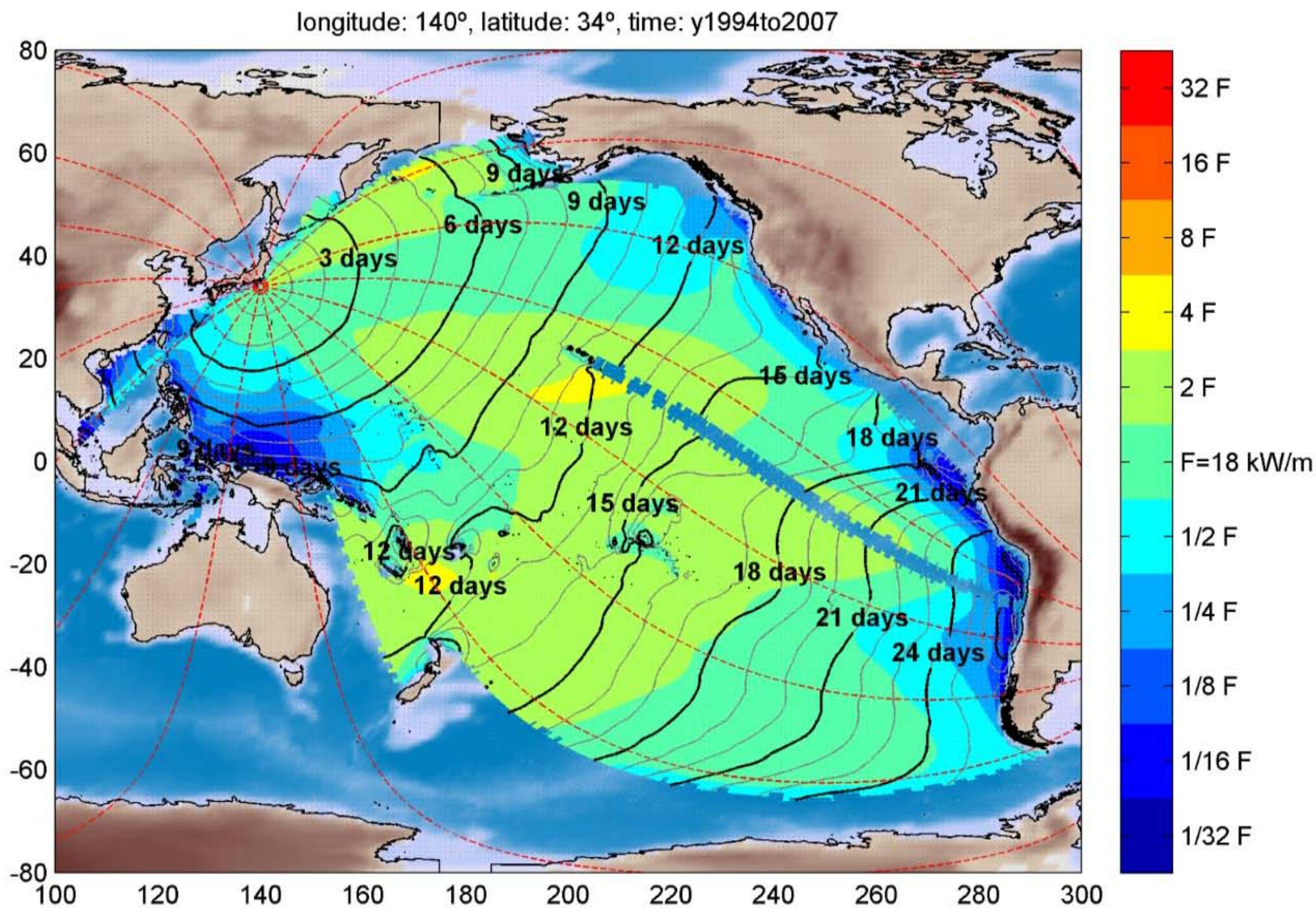
RESULTS: TRUJILLO, 1994-2007

Trujillo (Peru)



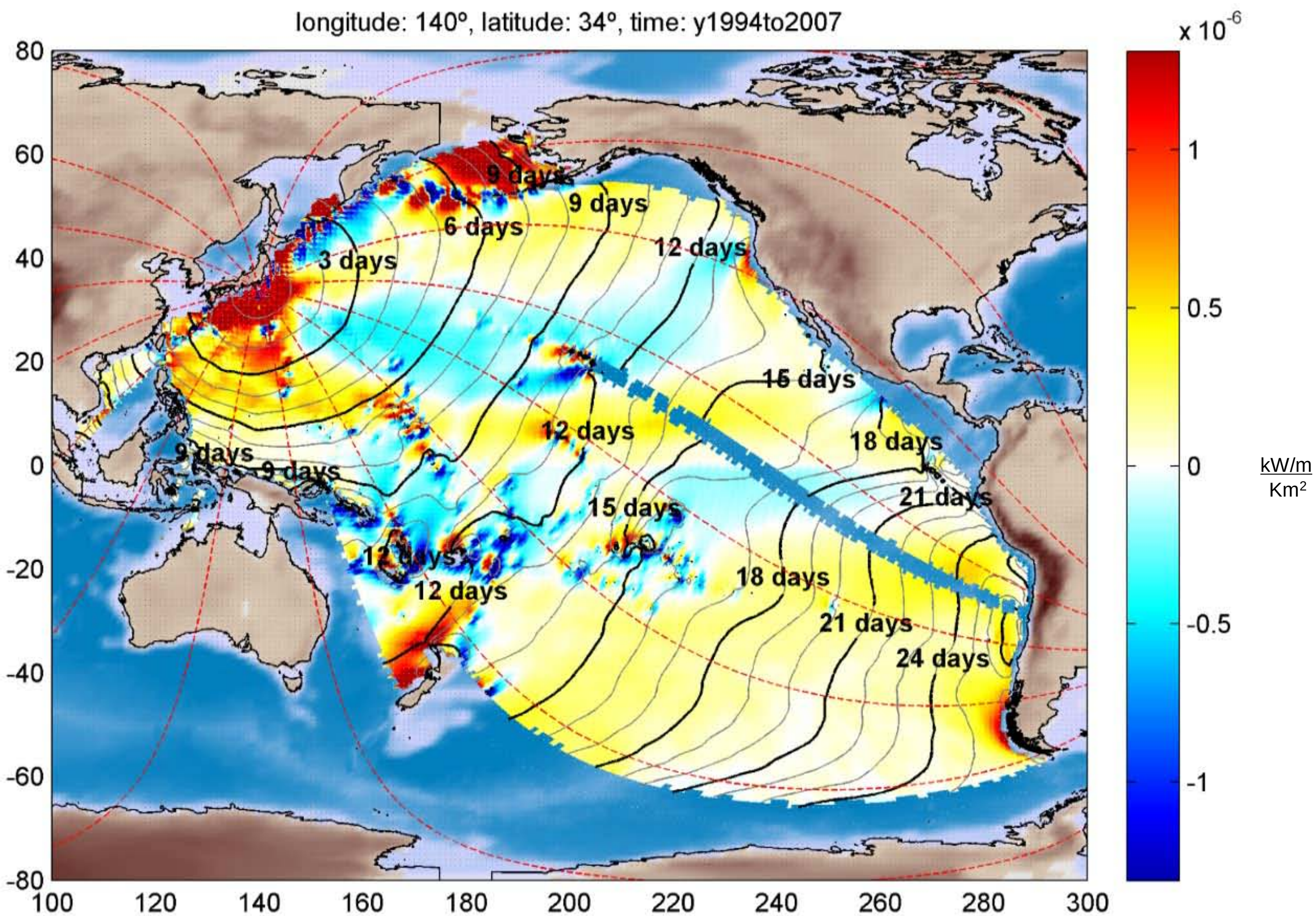
RESULTS: KAMOGAWA, 1994-2007

Kamogawa (Japan)



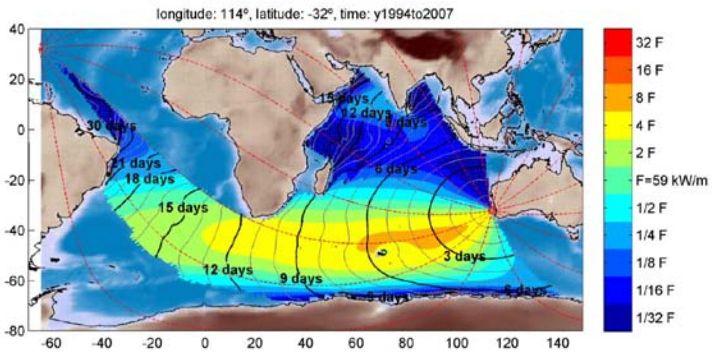
RESULTS: KAMOGAWA, 1994-2007

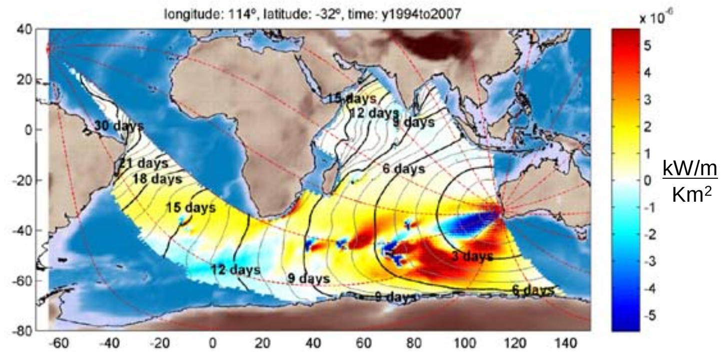
Kamogawa (Japan)



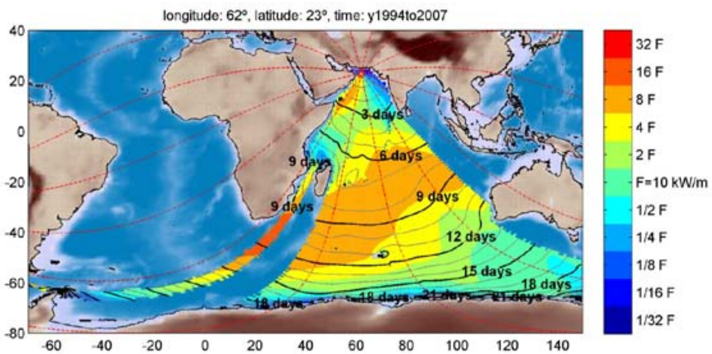
RESULTS: INDIAN OCEAN

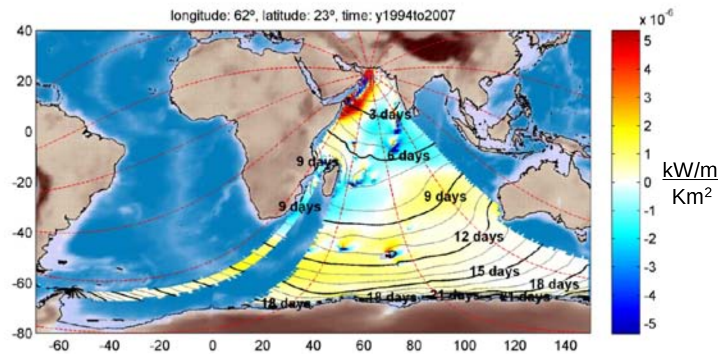
Perth (Australia)





Mascate (Oman)





CONCLUSIONS

- Results show **important spatial patterns** that cannot be directly inferred from local parameters
- The proposed method evaluates the **spatial influence of local wave climate** in different temporal scales from hours (**extreme events**) to years (**mean climate**).
- The zones of **generation/dissipation** of energy can be located, helping us to **define the optimal predictor area** for statistical downscaling or a better definition of meshes for dynamical downscaling.
- Validation with different climate analysis of other authors (Izaguirre et al., 2012; Alves et al., 2006) confirms the **robustness of the method**.

IHcantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

University of Cantabria
IH-Cantabria
http://www.ihcantabria.com

Marine Climate and Climate Change Group

A method to evaluate the generation area of local wave climate

Jorge Pérez (perezgj@unican.es)
Fernando J. Méndez (mendezf@unican.es)
Melisa Menéndez (menendezm@unican.es)

Acknowledgement This work was partially funded by projects "MAREN" (Marine renewable Energy , INTERREG, Atlantic Area Transnational program), "IMAR21" (CTM2010-15009 from the Spanish Government) and "GRACCIE" (CSD2007-00067, CONSOLIDER-INGENIO 2010 from the Spanish Government).

FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL Agua y Energía

European Geosciences Union
General Assembly 2013
Vienna | Austria | 07 – 12 April 2013