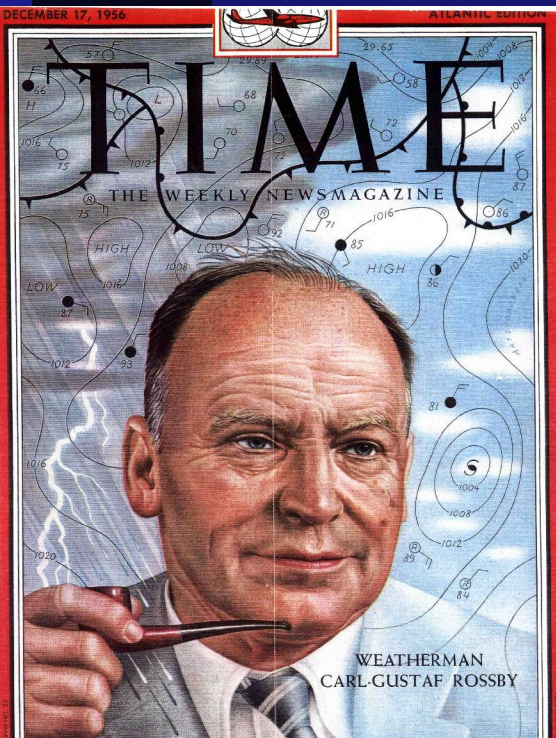


25 years of NWP at INM (1980-2005)

E. Rodriguez Camino



Outline

- First attempts (1967-1985).
- ECMWF LAM + SMHI ANAL (1986-1995)
- HIRLAM Project (1992→today)
- SRNWP EUMETNET Programme

Symposium on the 50th Anniversary of Operational Numerical Weather Prediction 14-17 June 2004, University of Maryland
(http://wwwt.ncep.noaa.gov/nwp50/Presentations/presentations_body.shtml)

Barotropic model



- Once the IBM 360/40 was acquired (around 1967) a suite based on the van Isacker's barotropic model was operationally run (R. Azcárraga).
- Hemispheric domain. It was only fed with radiosounding data at 500 mb. The final product arriving to forecasters was the historic - and also well know among our older forecasters- "zebra" maps.

Quasi-geostrophic 3 parameters model.

- 1979 → A new quasi-geostrophic 3 parameters model was coded from scratch (Hortal & García-Rendo) based on finite elements + OI analysis.
- An operational suite was maintained (1979→ 1982)
- Results were sent to the CAS NWP Project (1981-1982)

European Working Group on Limited Area Models (EWGLAM)

- The INM's NWP group joined EWGLAM (1979)
- Since then the INM's NWP group has actively participated in all meetings (the 26th meeting was held last year in Oslo)
- EWGLAM allowed exchange of information and experiences on operational NWP at European level.

ECMWF LAM (I)

- 1977 → a first trial of implementing the ECMWF LAM at INM was unsuccessful. This line was soon abandoned due to the lack of computing power for operations.
- 1983 → A new Fujitsu machine (FACOM M-382, 2 CPUs, 32 Mb, 12 MIPs) allowed to run ECMWF LAM
- 1985 Sept. → Suite based on ECMWF LAM (finite differences, $0.91^{\circ} \times 0.91$ 19L) + OI Anal (SMHI) (Hortal, Díaz-Pabón, Jimeno)

Predicción numérica del tiempo (I)

$$\frac{du}{dt} = -\frac{1}{\rho a \cos \phi} \frac{\partial p}{\partial \lambda} + fv + uv \frac{\tan \phi}{a} + F_\lambda$$

$$\frac{dv}{dt} = \frac{1}{\rho a} \frac{\partial p}{\partial \phi} - fu - u^2 \frac{\tan \phi}{a} + F_\phi$$

$$\frac{\partial p}{\partial z} = -\rho g$$

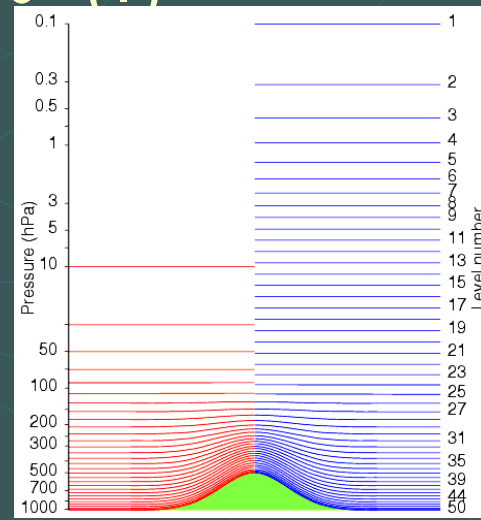
$$\frac{\partial \rho}{\partial t} = -\nabla \cdot \rho \mathbf{V}$$

$$p = R \rho T$$

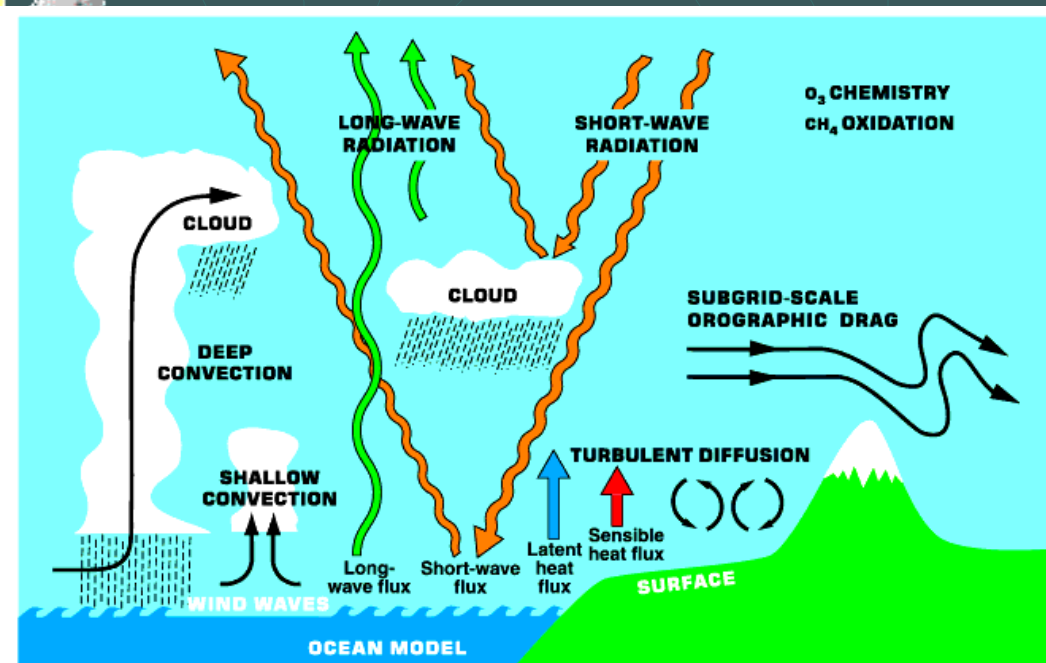
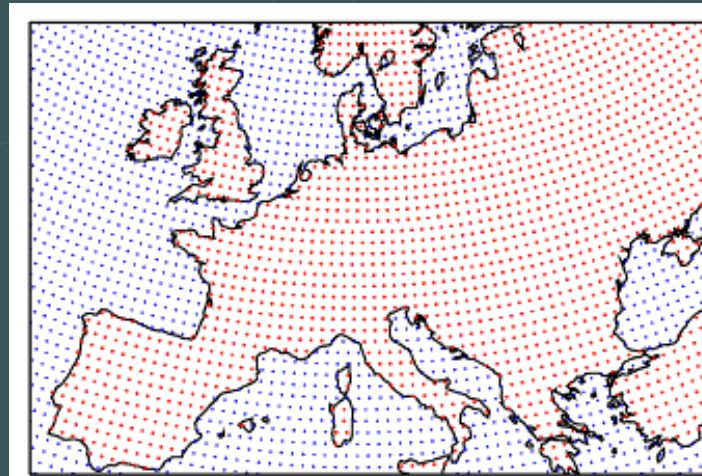
$$C_p \frac{d\Theta}{dt} = \frac{\Theta}{T} Q$$

u, v, w, p, ρ, T

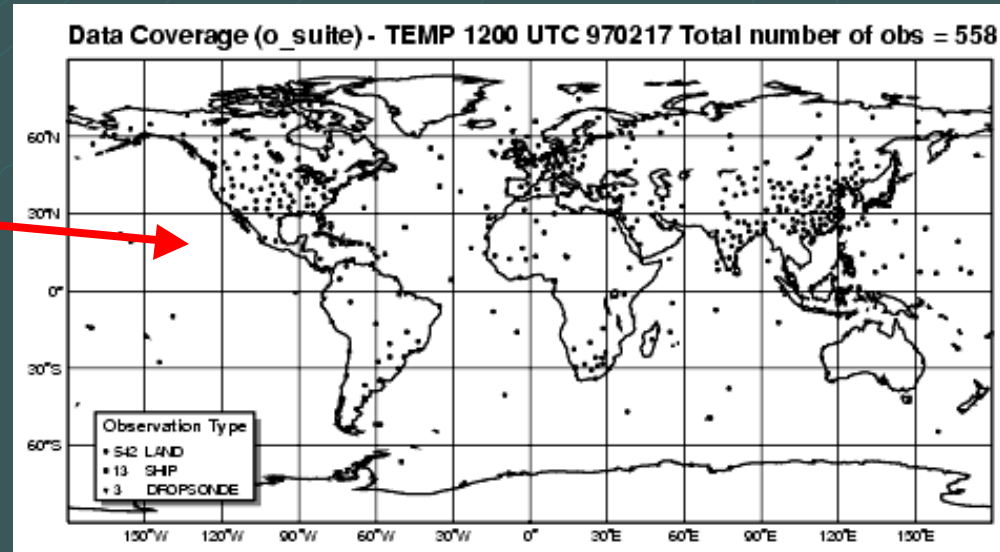
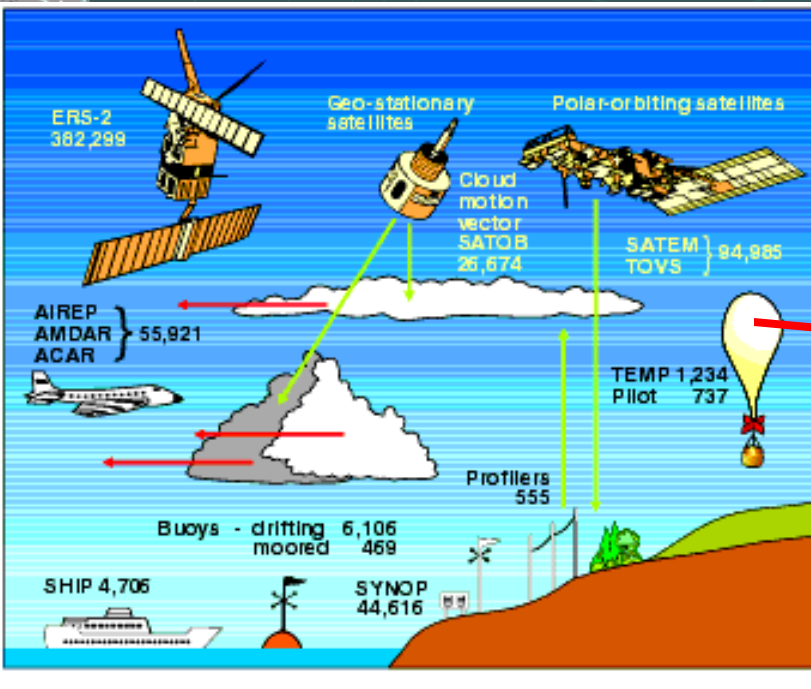
Ecuaciones primitivas



Discretización



Predicción numérica del tiempo (II): condiciones iniciales



+ Algoritmo de asimilación (variables del modelo, interpolación, filtrado de escalas)

ECMWF LAM (II)

- Experimentation based on this suite (ECMWF LAM + OI SMHI) mainly focused on Mediterranean cyclogenesis, different physics options, resolution, initialization, OSE, bogus data, etc.
- “Perfect toy to play with” . I personally learnt a lot running experiments with this implementation.

HIRLAM Project

- 1992 → our NWP group approached the HIRLAM Project.
- At that time HIRLAM was the only consolidated European cooperation to develop NWP models [apart from the 3 big groups (UKMO, MF, DWD)]. Only these big groups had enough critical man power mass to develop NWP models. Later on new consortia appeared (ALADIN, COSMO, UKMO)!

INM in HIRLAM3 Project

- 1994 → INM started a formal cooperation with HIRLAM Project, first as an associate member (not full member!). This meant that we contributed with staff for developments and we had not the whole ownership of the code (only permission to use it at INM!) (1994-1996, HIRLAM3 Project)
- INM contributed to HIRLAM3 mainly with work on 3DVAR assim, surface analysis, cond/conv, surface, turbulence. Our group specialized mainly in physics and data assimilation.

EUMETNET



EUMETNET

The Network of European Meteorological Services

<http://www.eumetnet.eu.org>

- # EUCOS
- # E-AMDAR
- # E-ASAP
- # AWS
- # SWS
- # OPERA
- # OBS-INFO
- # Radiosonde
- # TIPS
- # SRNWP
- # ECSN

WG-ENV

MAPS-NWS

The Network of
18 National Meteorological Services

Austria
Belgium
Denmark
Finland
France
Germany
Greece
Iceland
Ireland
Italy
Luxembourg
Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom

V Simp
INN

20-23/7/2001

Short Range NWP (SRNWP) Network → EUMETNET progr.

- Network of a few Lead Centres specialized on different NWP topics (SMHI, 1994)
- INM/SMHI tandem Lead Centre on surface processes and assimilation of surface variables.
- From 1994 on, EWGLAM and SRNWP meetings are held together. Germ of the European cooperation on NWP

SRNWP (Short Range Numerical Weather Prediction)

- The SRNWP Working Group was established in 1993 by ICWED (Informal Conference of Western Europe Directors of NMSs). Since then it has been "organising the competition" between the different teams active in Europe for the development of numerical weather prediction models.
- Lead Centres are selected by the group for different topics. The Lead Centres have the responsibility to organise intercomparisons, and workshops and to ensure the flow of information between participants.

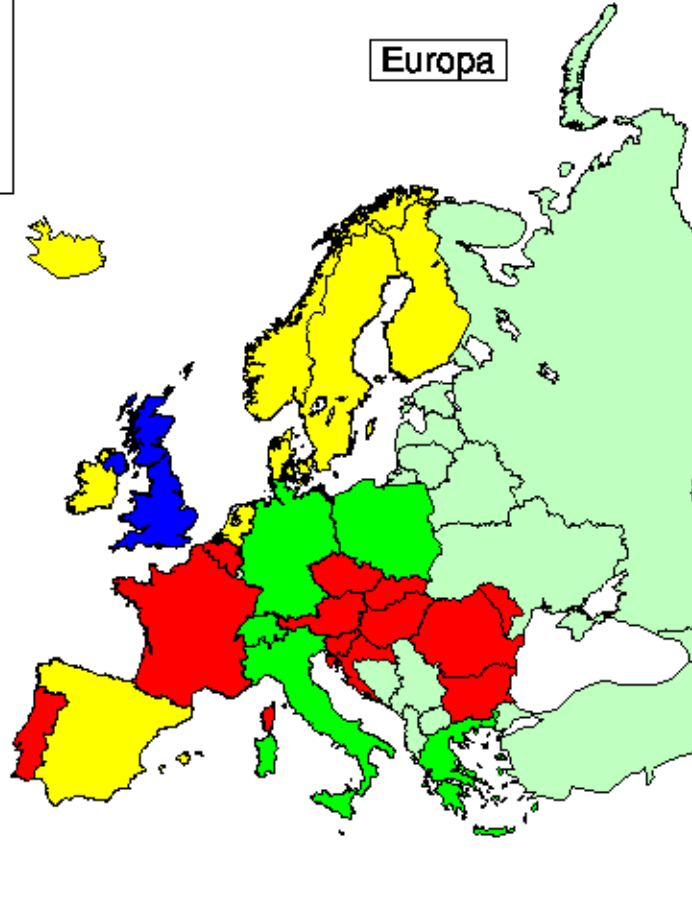
The currently active topics are :

- ◆ variational methods (lead centre UKMO)
- ◆ non-hydrostatic modelling (lead centre COSMO / DWD)
- ◆ numerical techniques (lead centre ALADIN / Météo-France)
- ◆ soil analysis and soil processes (lead centre HIRLAM // INM / SMHI)
- ◆ statistical and physical adaptation (lead centre LACE / ZAMG)
- ◆ mesoscale verification (lead centre HIRLAM / KNMI)

Europa
av Kolumn B

■	ALADIN	(12)
■	COSMO	(5)
■	HIRLAM	(8)
■	UK	(1)

Europa



LAM evolution (1985→now)

SYNOPTIC MODEL (Eur+North Atl)

$0.91^\circ \times 0.91^\circ$ (lon/lat) → $0.5^\circ \times 0.5^\circ$ (lon/lat) → $0.15^\circ \times 0.15^\circ$ (rot)

19L

31L

40L

Nested Spanish area model

$0.45^\circ \times 0.45^\circ$ (lon/lat) → $0.2^\circ \times 0.2^\circ$ (lon/lat) → $0.05^\circ \times 0.05^\circ$ (rot)

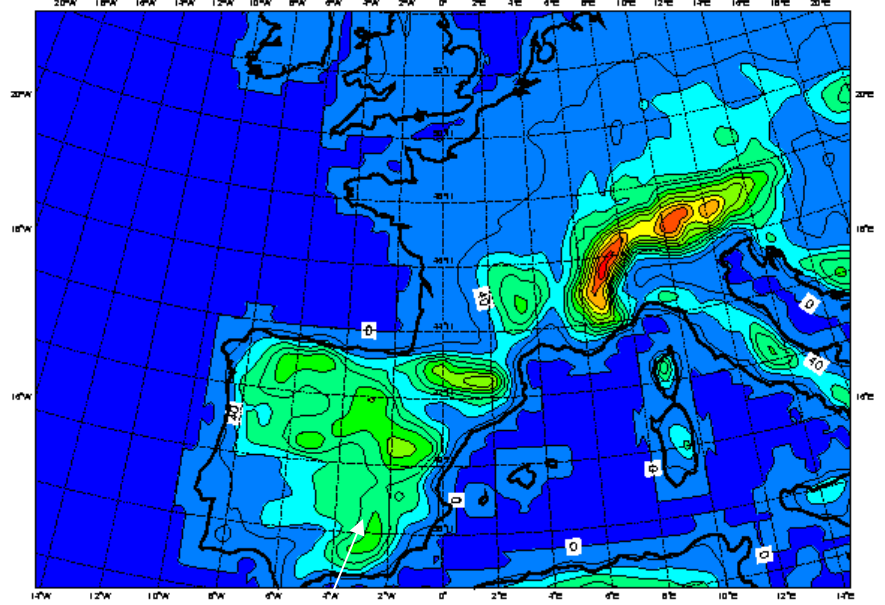
19L

31L

40L

HIRLAM REF: Orografía y Area Hirlam05

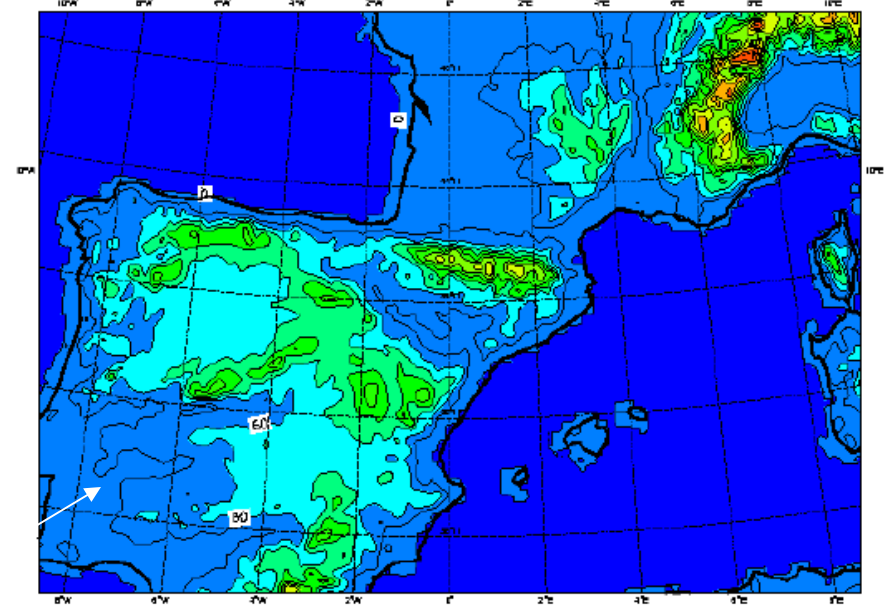
Analysis 00/06/2000 00 Z, H + 000 -- Val 00/06/2000 00 Z



MAGICS 5.3 calma - png Tue Jun 1 11:33:13 1999 HIRLAM

HIRLAM BE3: Orografía y Area Hirlam025

Analysis 01/01/2001 00 Z, H + 000 -- Val 01/01/2001 00 Z

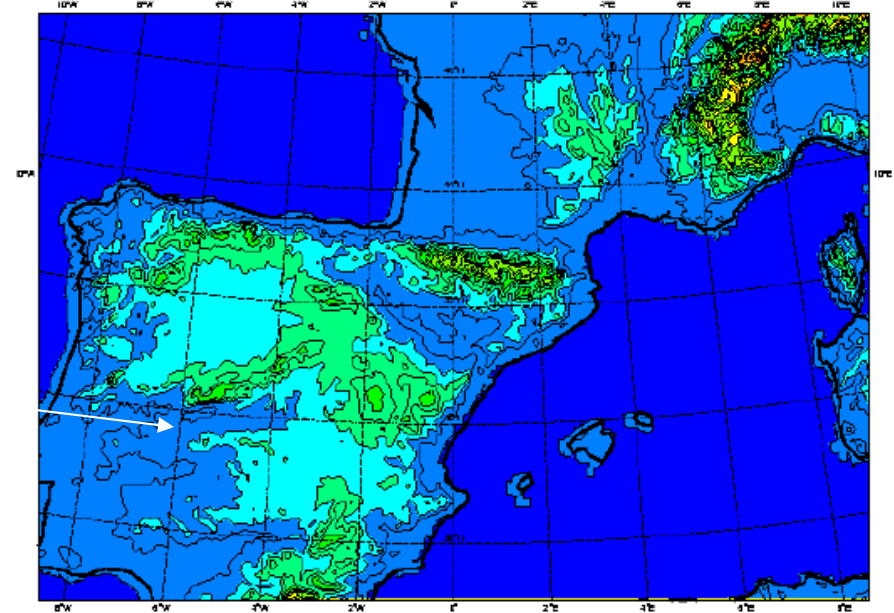


MAGICS 5.3 calma - png Thu Apr 26 18:24:37 2001 HIRLAM

0.5°
0.15°
0.05

HIRLAM BE5: Orografía y Area Hirlam025

Analysis 01/01/2001 00 Z, H + 000 -- Val 01/01/2001 00 Z



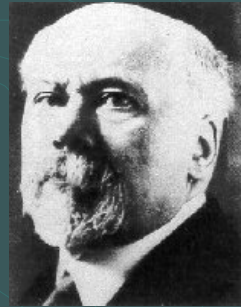
MAGICS 5.3 calma - png Thu Apr 26 18:22:51 2001 HIRLAM

Caos y predicción del tiempo (I)

- La atmósfera es un sistema caótico: pequeños errores en las CI se magnifican rápidamente afectando a la predecibilidad del tiempo. Además la predecibilidad viene limitada por las aproximaciones introducidas en los modelos (discretización , parametrizaciones físicas, etc.).
- Límite a las predicciones deterministas basadas en unas únicas CIs => Predicción mediante conjuntos o poblaciones

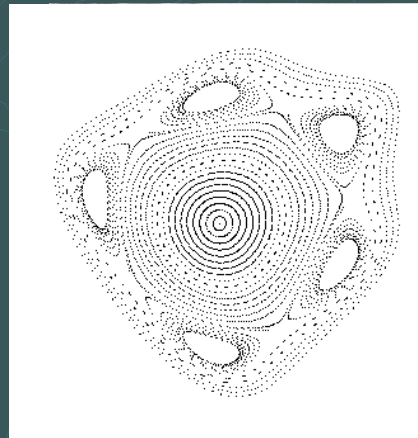
Caos y predicción del tiempo (II)

- Un precedente hoy casi olvidado: H. Poincaré.
- Estableció a principios del s. XX y para temas de dinámica celeste los principios básicos del comportamiento caótico: fuerte dependencia de las CIs, complejidad de las trayectorias, problema de los 3 cuerpos, etc.
- Padre de la teoría de sistemas dinámicos, tal y como la concebimos en la actualidad.



Caos y predicción del tiempo (III)

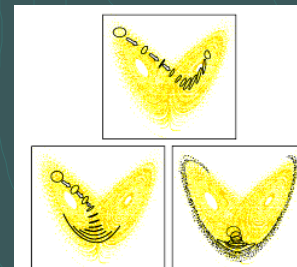
- Otro precedente: Kolmogorov
- En 1954 presentó su teoría general de los sistemas dinámicos y dinámica clásica. Teoría KAM (Kolmogorov, Arnold y Moser): comportamiento topológico global de las trayectorias de los sistemas hamiltonianos.



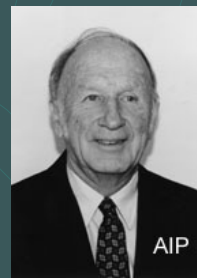
Caos y predicción del tiempo (IV)

$$\begin{aligned} \dot{X} &= -\sigma X + \sigma Y \\ \dot{Y} &= -XY + rX - Y \\ \dot{Z} &= XY - bZ \end{aligned}$$

Sistema de Lorenz
(1969)



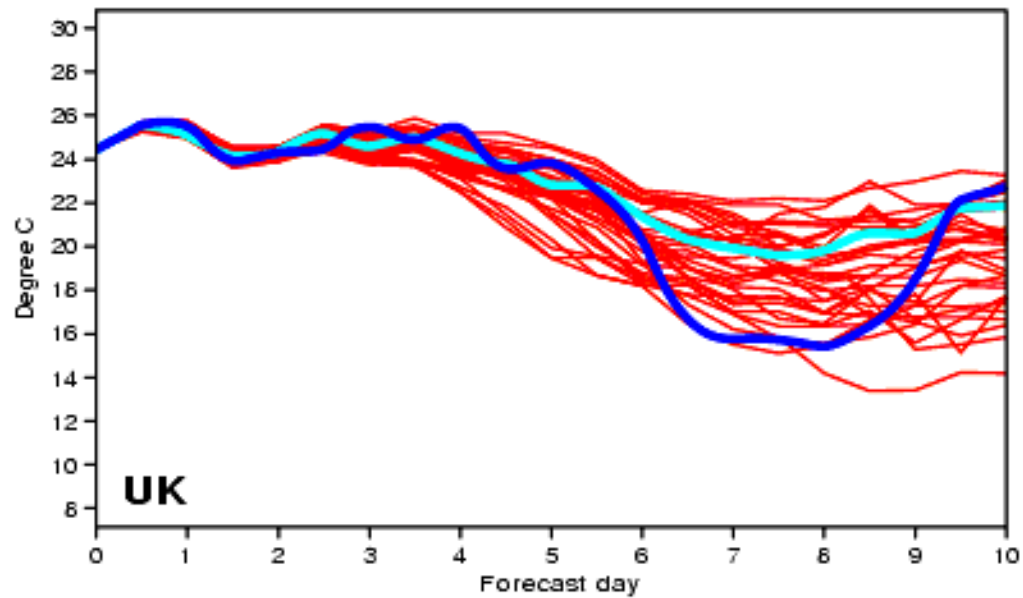
Divergencia
pequeña \leftrightarrow Alta
Predecibilidad



ECMWF ensemble forecast - Air temperature

Date: 26/06/1995 London Lat: 51.5 Long: 0

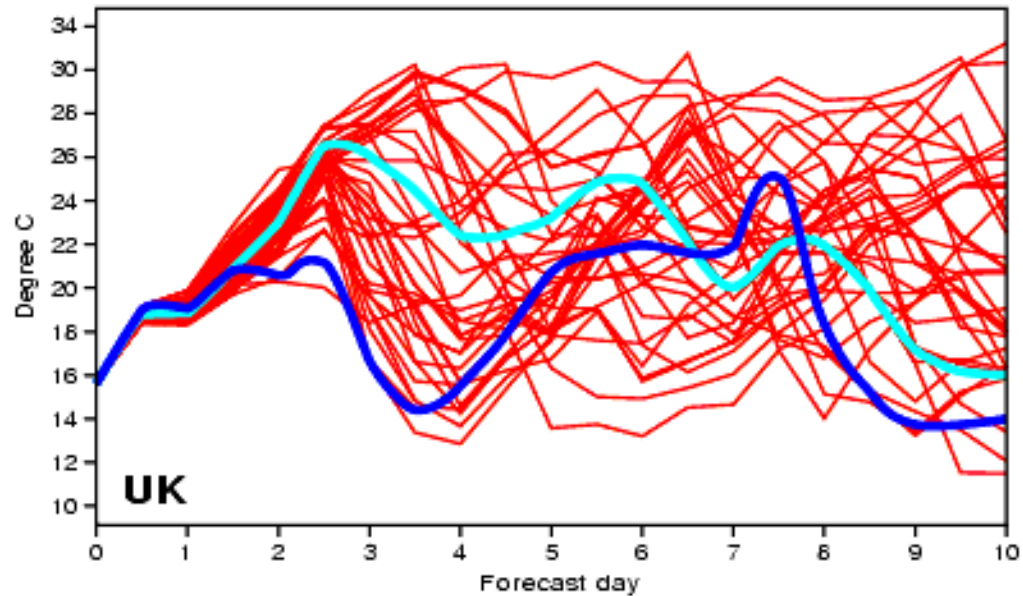
Control Analysis Ensemble



ECMWF ensemble forecast - Air temperature

Date: 26/06/1994 London Lat: 51.5 Long: 0

Control Analysis Ensemble



My personal last 25 years



- After PEP, 3 years as observer at Barcelona airport
- 1986



- Two consecutive courses (WMO Class II and I)
- 2001
- 19 years working on NWP [+1 year in US+many frequent short visits to HIRLAM countries]
- 2002





That's all folks,
for the time being!