PREDEX
PREDictability of EXtreme weather events

http://empslocal.ex.ac.uk/people/staff/rv211/predex.html

Renato Vitolo

Exeter Climate Systems

College of Engineering, Mathematics & Physical Sciences
University of Exeter

www.secam.ex.ac.uk/xcs

r.vitolo@exeter.ac.uk

Complexity-NET outreach workshop
Brussels, 9-10 Nov 2010

Objective:

To deliver & apply new methods for quantifying the predictability of extreme events in complex dynamical systems.

Questions:

1. What are the deterministic time limits of predictability for extreme weather events?
2. How can we use emergent dynamical patterns to enhance predictability of extreme weather events?
3. What is the role of spatial scale interactions in the physical processes leading to extreme weather?

Approach:

combination of ideas from dynamical systems, statistics, meteorology & atmospheric physics.

Duration: September 2010 - 31 August 2012.

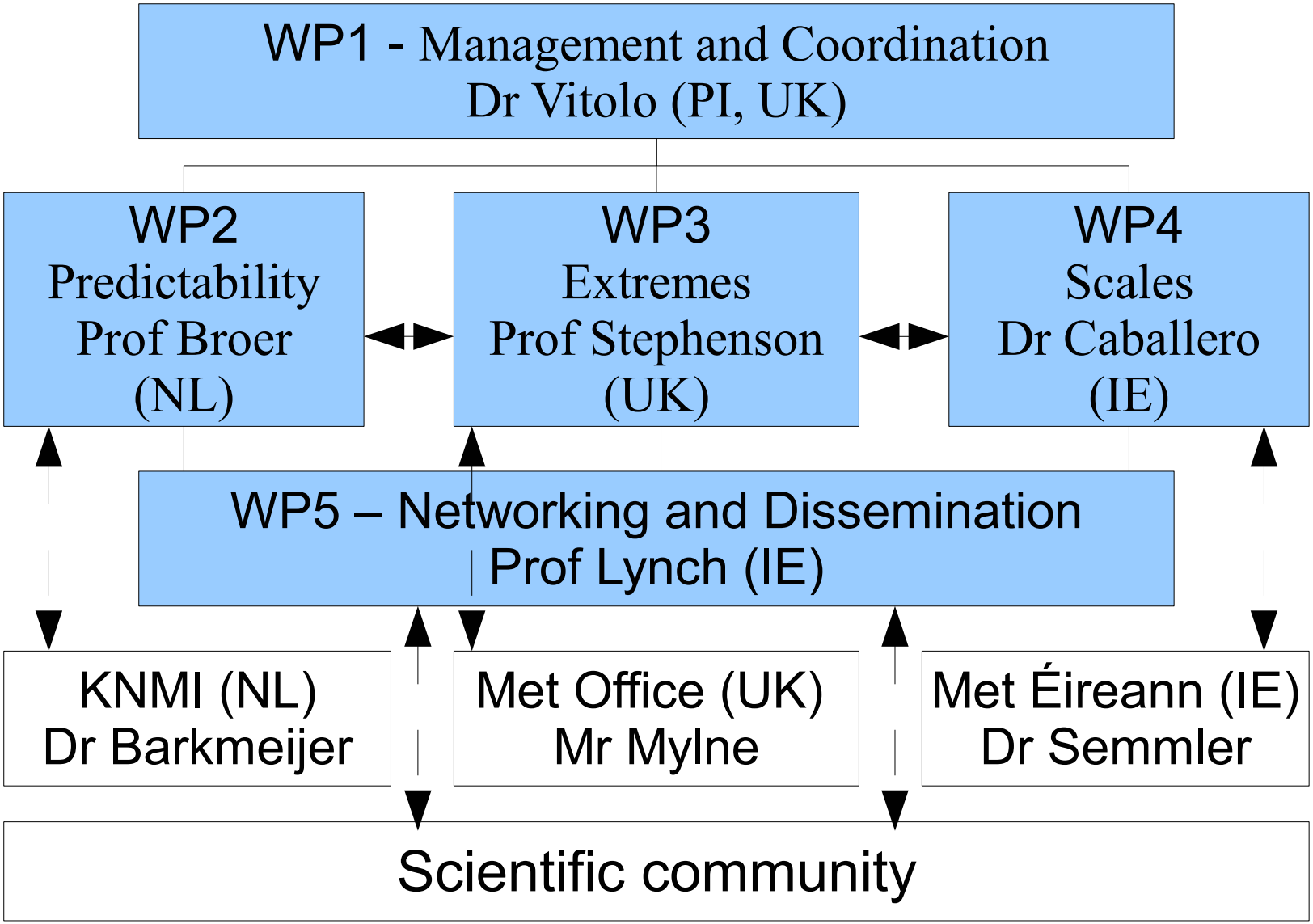
Partner countries: UK, **IE**, **NL**

Research group	Institution		Disciplines
Exeter Climate Systems research centre	University of Exeter	UK	climate, maths, stats
Meteorology & Climate Centre	University College Dublin	IE	atmos. physics, meteorology
Dynamical Systems & Mathematical Physics	University of Groningen	NL	maths

Stakeholders: national weather forecasting services:

- UK Met Office;
- Irish Met Éireann;
- KNMI (Royal Netherlands Meteorological Institute).

PREDEX structure



Dr C Ferro (Exeter) will contribute to WP3.

PREDEX: basic scientific idea

Statistical theory of **extreme values** (EVT) yields universal models for the probability distribution of large events.

Formulated traditionally for stochastic processes: sequences of random variables $X_1, X_2, \ldots$.

Recent progress by UK-based PREDEX investigator Dr Mark Holland has extended EVT to **chaotic deterministic systems**:

systems governed by evolution laws (e.g. differential equations) with **limited temporal predictability** due to growth of errors in initial conditions.

Goal:
to exploit **dynamical behaviour** to quantify/enhance predictability of extremes in deterministic systems.

Work Package 2

Leader: Prof Henk Broer, Univ. Groningen, NL

Main deliverable:
New mathematical tools to assess predictive time limits for extremes in deterministic dynamical systems.

Approach:

- study dynamical systems of low (1,2,3) dimension, e.g. intermittency maps, Hénon, Lorenz '63;
- study effect of bursting or temporally clustered behaviour on extremes & their predictability;
- further develop ergodic theory of extremes for low-dimensional dynamical systems.

Work Package 3

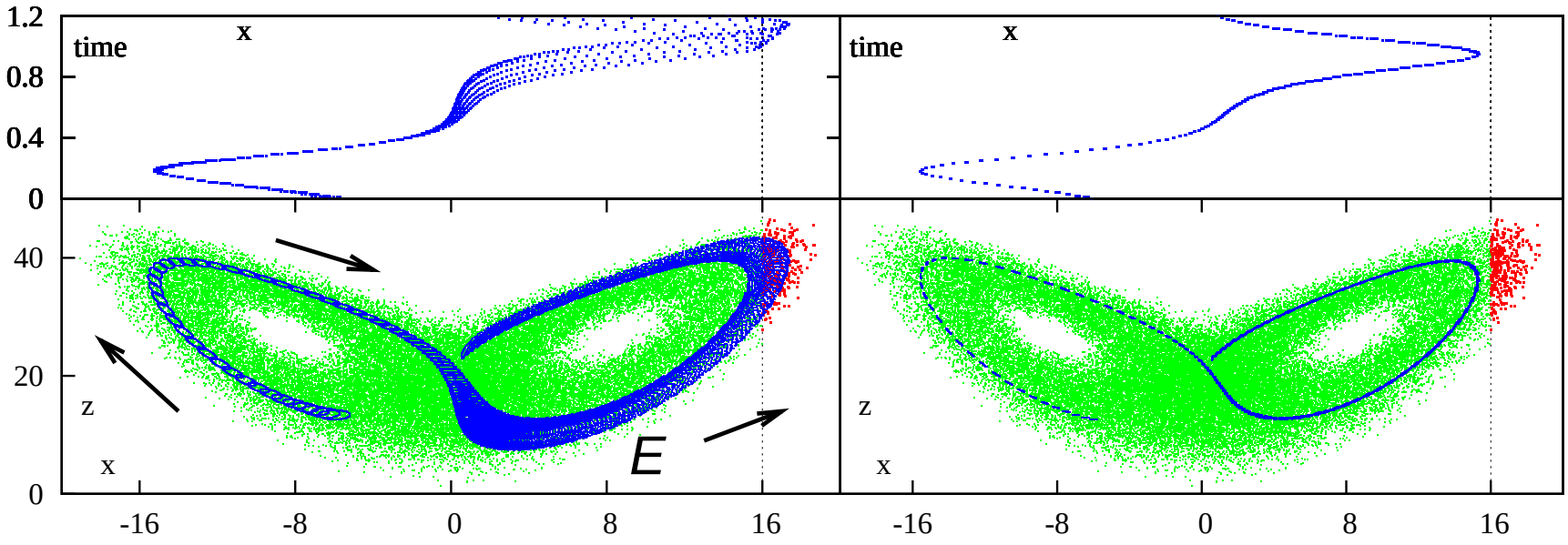
Leader: Prof David Stephenson, Univ. Exeter, UK

Main deliverable:
New ensemble forecast techniques for extreme events in atmospheric models of low- and high dimensionality.

Approach:

- study idealised dynamical systems (dimension $\sim$100-1000) for midlatitude atmospheric circulation;
- study predictability of large-scale, low-frequency atmospheric circulation patterns inducing clustering (temporal modulation) in arrival rate of windstorms;
- develop “bespoke” ensembles to quantify predictive uncertainty of low-probability events;
- apply forecast verification tools for extreme events developed by Prof Stephenson & Dr Chris Ferro (Exeter).

Top: time evolution of cost function ϕ on ensembles of bottom.



Bottom: phase-space evolution of 2 ensembles around point on Lorenz '63 attractor with same radius but different orientation.

Extremality region E: where ϕ is large.

Right ensemble: no trajectory intersects extremality region.
$\rightsquigarrow$ need for **bespoke ensemble design**.

Work Package 4

Leader: Dr Rodrigo Caballero, Univ. College Dublin, IE

Main deliverable:
Identification of precursors of extreme meteorological events.

Approach:
study long simulation of full-complexity, fine-resolution operational numerical weather forecasting model (BOLAM, large dimensionality) on North Atlantic & Western Europe, embedded in coarse-resolution climate model.

- large-scale influence on clustering of windstorms;
- energetics of the small- vs. large-scale systems: two-way cross-scale energy flow?
- predictability of specific extreme windstorms.

Beyond PREDEX...

Broaden applications to other potential stakeholders:

- energy sector (e.g. windfarms, ocean waves);
- environmental agencies;
- insurance firms (e.g. Willis Research Network).

Example:
Emerging discipline: catastrophe finance for climate risk.

To get more capacity: financial markets are required to enter the insurance game (especially in 3rd world countries).

NEED MORE (PREDICTIVE) INNOVATIVE SCIENCE!

Development of new financial tools e.g. “Index Insurance for Climate Risk Management & Poverty Reduction” (http://iri.columbia.edu/publications/search.php?id=556)