The Socio-Economic and Environmental Benefits of a Revolution in Weather, Climate and Earth-System Prediction

Document 22:
Task CL-07-01 White Paper prepared under Co-Leadership of

The Socio-Economic and Environmental Benefits of a Revolution in Weather, Climate and Earth-System Prediction

Melvyn Shapiro, Jagadish Shukla, Brian Hoskins, John Church, Kevin Trenberth, Michel Béland, Guy Brasseur, Mike Wallace, Gordon McBean, Jim Caughey, David Rogers, Gilbert Brunet, Leonard Barrie, Ann Henderson-Sellers, David Burridge, Tetsuo Nakazawa, Martin Miller, Philippe Bougeault, Rick Anthes, Zoltan Toth and Tim Palmer

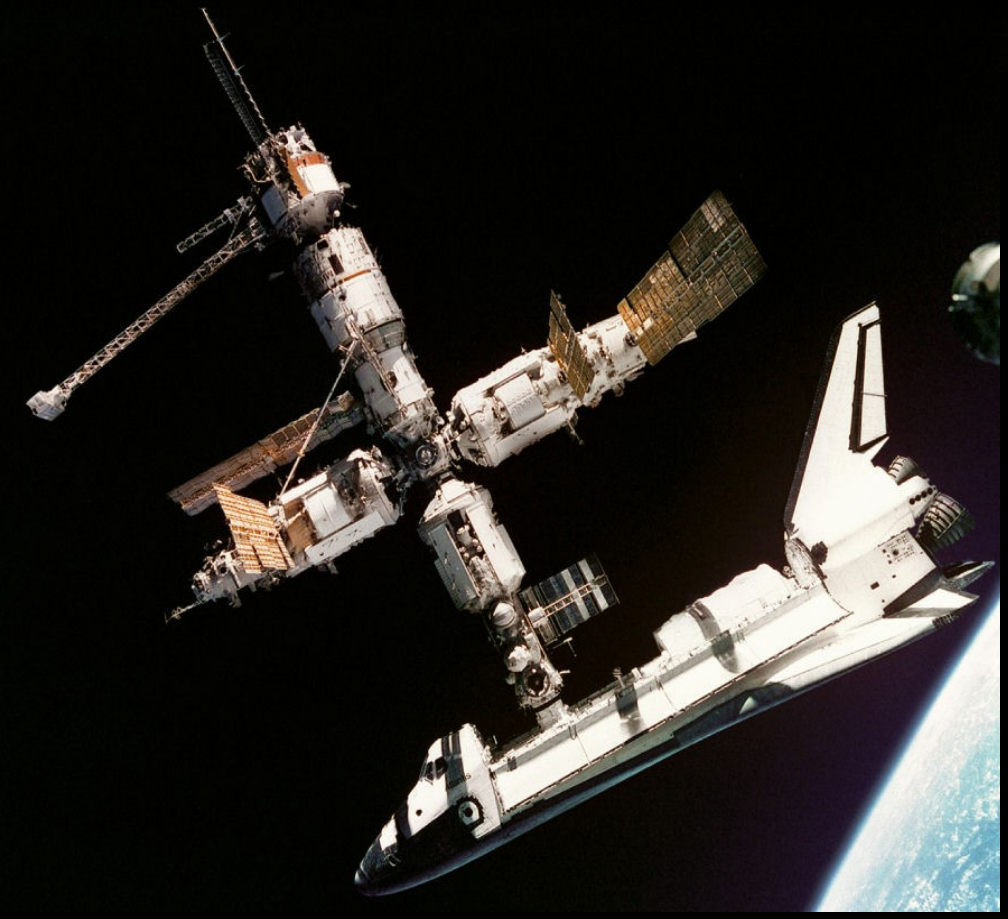
Representing academic and operational-services communities

A Weather, Climate and Earth-System Prediction Project for the 21st Century

A Weather, Climate and Earth-System Prediction Project for the 21st Century

- Increase our capacity to mitigate and adapt to socio-economic losses arising from high-impact weather and climate
- Realize the full benefits from the observation, prediction and early-warning system components of Global Earth Observing System of Systems (GEOSS)

The proposed ***Project*** is comparable to the International Space Station and Hubble Telescope



with a socio-economic benefits-to-cost ratio that is much higher

PROJECT ELEMENTS

- **Decision Information** to mitigate and adapt to the impact of weather and climate hazards
- **High-Resolution Forecast Models** of the atmosphere, ocean, land, bio-geochemical and socio-economic processes
- **Advanced Data-Assimilation Systems** that enhance the use of observations from space, land and ice surfaces, and oceans
- **Science and Technology Transition** into operational products and services
- **Education, Science and Technology Projects** to enhance government and public awareness of the value and utilization of weather, climate, environmental and socioeconomic information

Uses for environmental information products

In Energy Industry Operations

- Energy load forecasting across grids
- Fuel mix determination
- Thermostat control
- Wind farm siting

In the Health Industry

- Health forecasts
- Spread of toxins and pollutants both airborne and waterborne
- Famine, flood, and drought climate forecasts
- Health facility scheduling

Other sectors---other uses

In the Transportation Industry

- Ship route optimization and planning
- Aviation routing and planning
- Intermodal transportation optimization
- Trucking industry logistics

In the Finance Industry

- Risk rating for compliance
- Weather derivatives for trading, futures and hedging
- Environmental evaluation for asset managers

In the Tourism and Leisure Industry

- Infrastructure planning for new construction
- Training courses for staff development programs
- Seasonal planning for resort load capacity
- Hazard and risk management preparation
- Leisure line route planning and recreational boating

Driving Principles for Managing with Environmental Information

- Regulatory
- Decision Accountability/Shareholder Value
- Safety of Life and property
- Market Economics & Competitive Advantage
- Risk reduction
- Reliability, Efficiency, Sustainability
- Corporate Social Responsibility- Indices

Energy Operations Aided by Reductions in Environmental Forecast Uncertainty

- Sales/earnings forecasting
- Energy storage replenishment strategies
- "Flexible" energy production and delivery
- Storage requirements needs assessment
- Storage logistics planning
- Regional Energy mngt. planning
- Stockpile planning
- Seasonal demand forecasts
- Delivery rate setting
- Hydo regional water mngt. Strategy
- Compliance projections estimates

Forecast Uncertainty

Years

Seasons

Months

8 – 14 Days

6 – 10 Days

Days

Hours

Minutes

Forecast Uncertainty

- Customer billing service
- Pump load forecasting
- Fuel supply forecasting
- Energy switching strategy
- Distributed generat. mngt.
- Maintenance scheduling
- Sequestration timing
- Inventory management
- Pipeline throughput mngt.

- Infrastructure design
- Regional infrastructure plan
- New storage capacity plans
- Mitigation strategy design
- Plant/ infrastructure siting
- Energy grid adaptation plans
- Energy policy setting

- Tariff calling
- Utility grid management
- Wind generation dispatch
- Hydo supply management
- Ship/tanker routing
- Refining operations mngt.
- Pipeline laying logistics

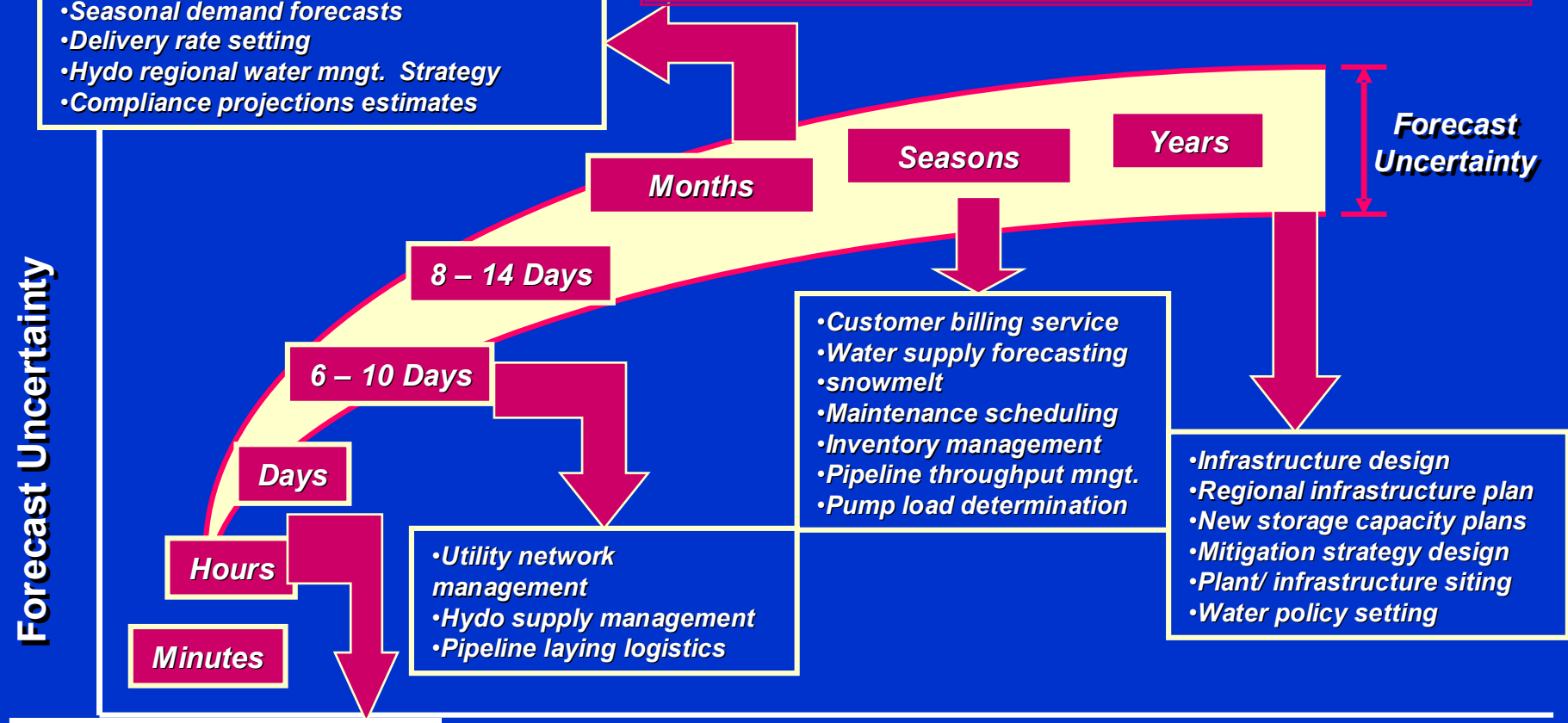
- Load balancing
- Electricity pricing/ trading
- Outage/surge mngt.
- "Intelligent" infrastructure
- "Net metering"
- Dispatch management
- Hazard response
- Platform operations

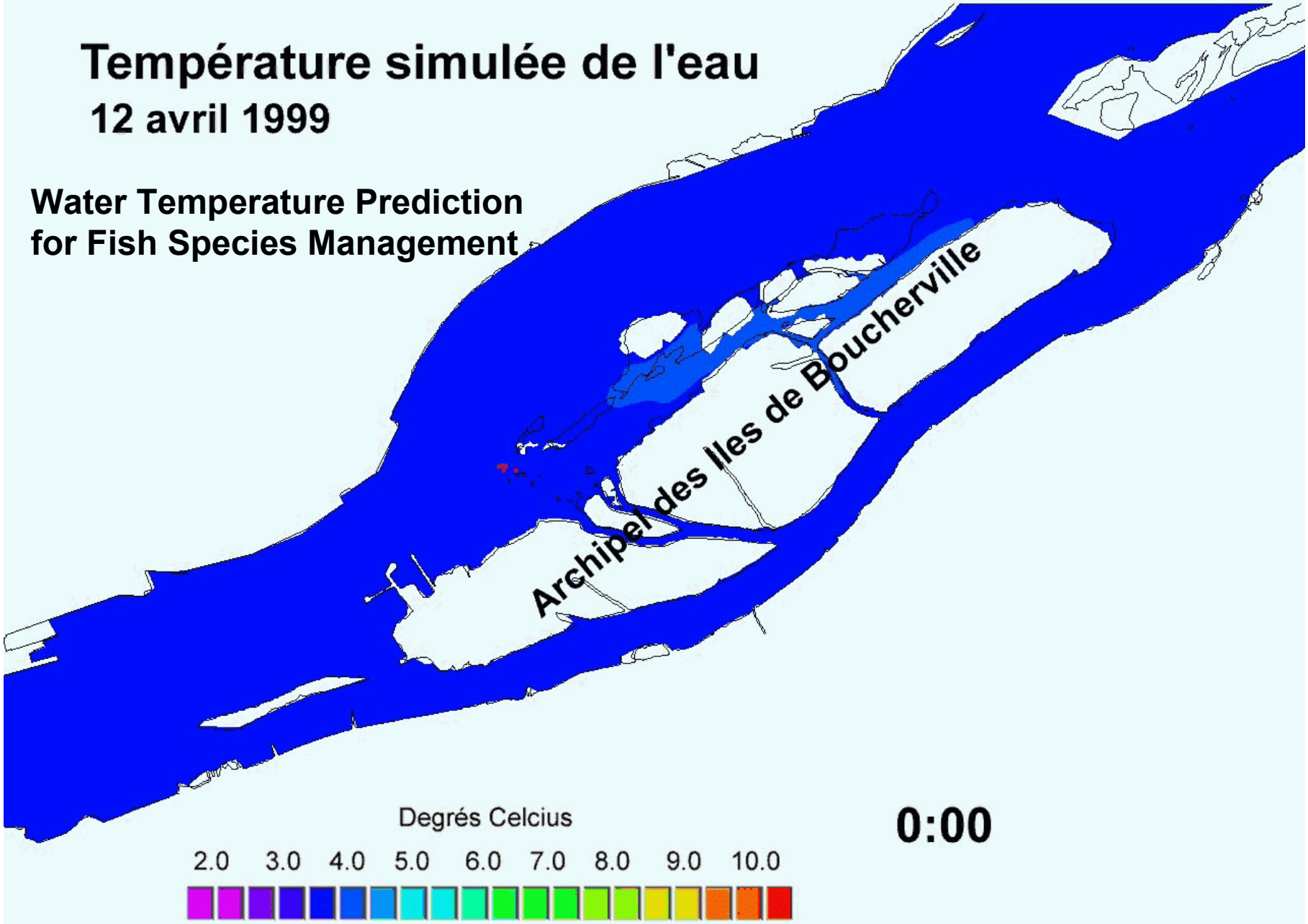
Forecast Lead Time

Critical forecast periods
Sub day, 2-4 day, 90 day

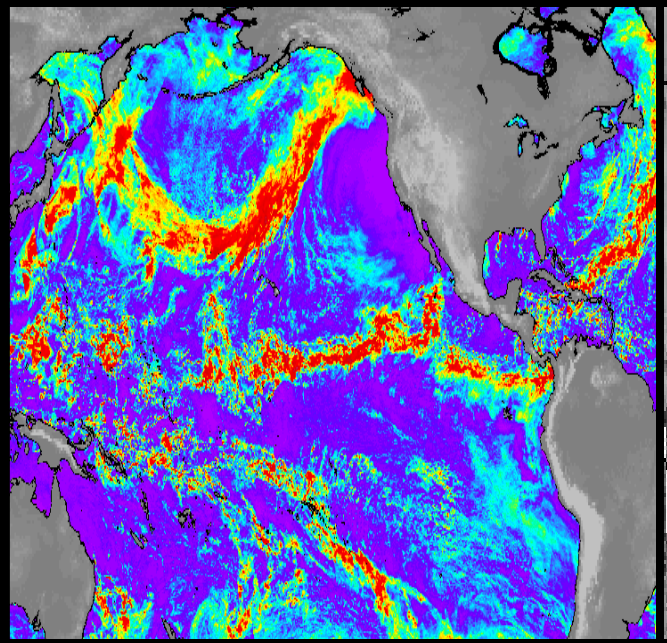
Water Operations Aided by Reductions in Weather/Climate Forecast Uncertainty

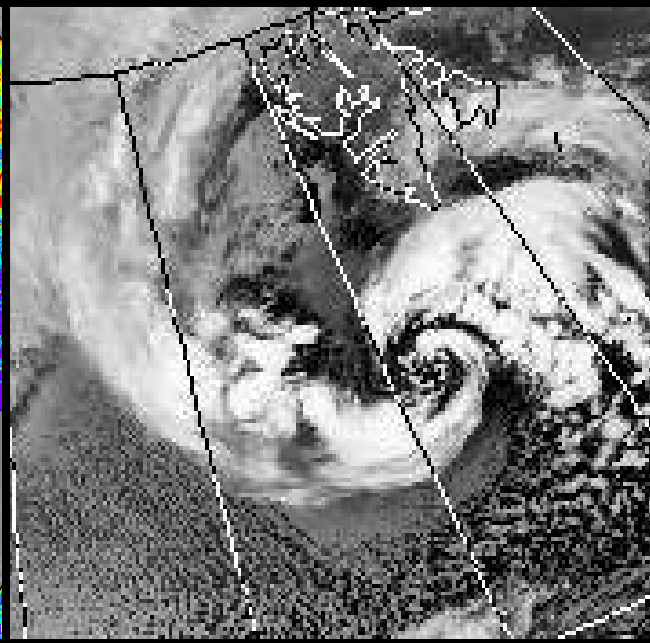
- Sales/earnings forecasting
- Water storage replenishment strategies
- "Flexible" water production and delivery
- Storage requirements needs assessment
- Storage logistics planning
- Regional Water mngt. planning
- Stockpile planning
- Seasonal demand forecasts
- Delivery rate setting
- Hydo regional water mngt. Strategy
- Compliance projections estimates

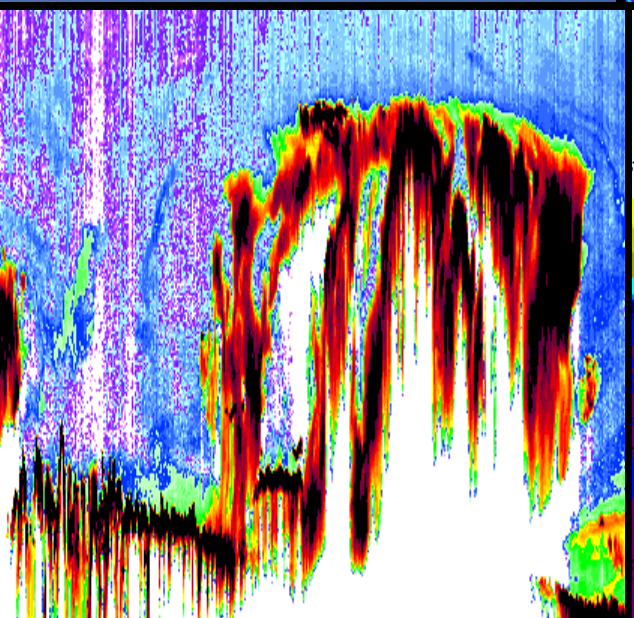


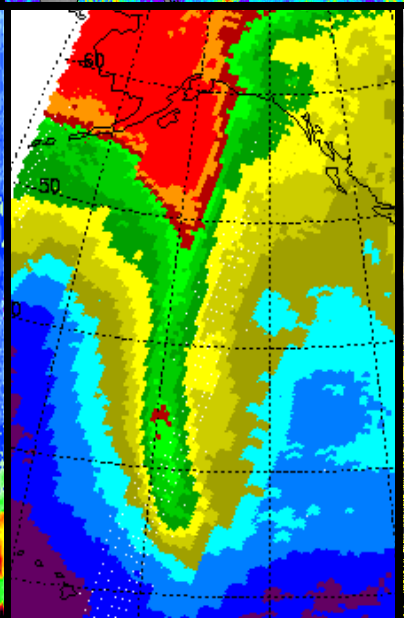

Température simulée de l'eau
12 avril 1999
Water Temperature Prediction
for Fish Species Management
Archipel des Iles de Boucherville
Degrés Celcius
2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
0:00

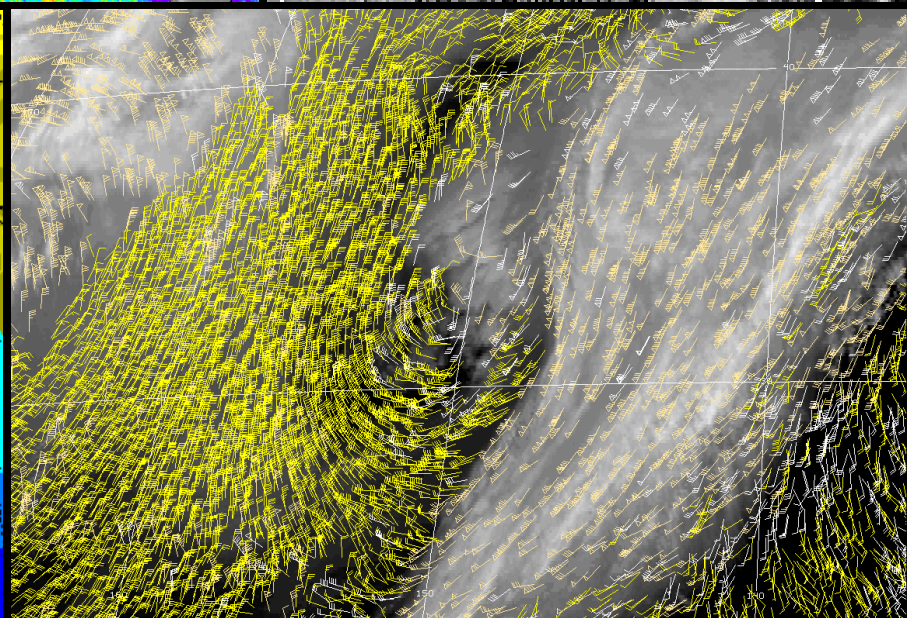
Present and Future Observing Systems

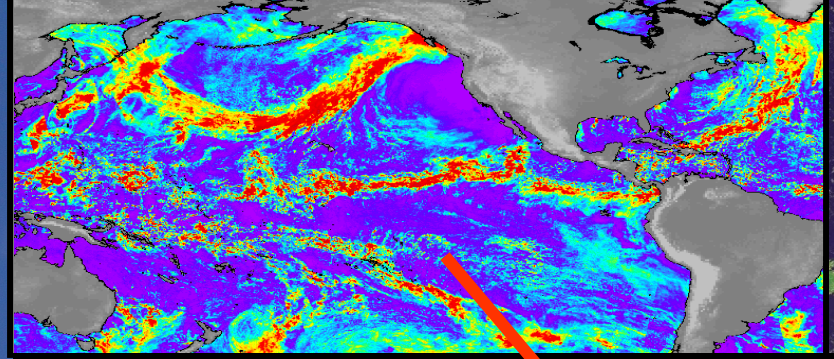




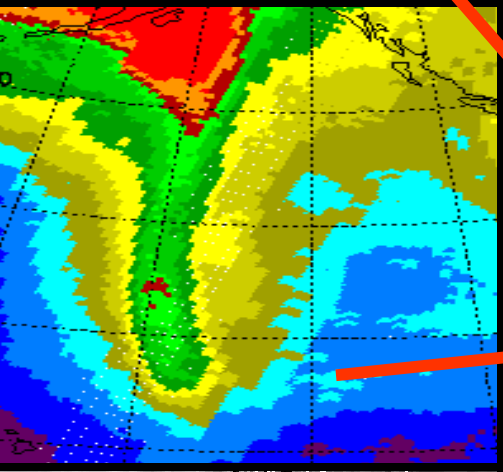


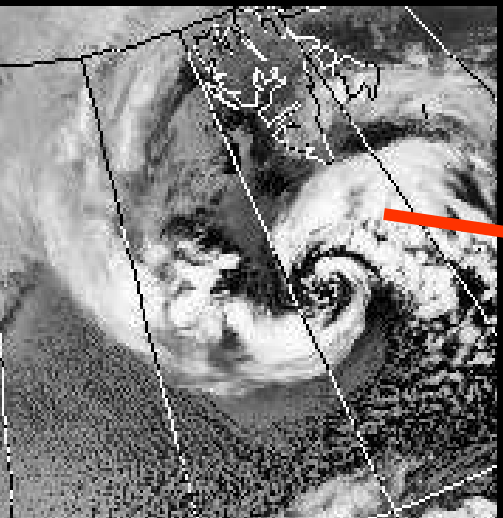


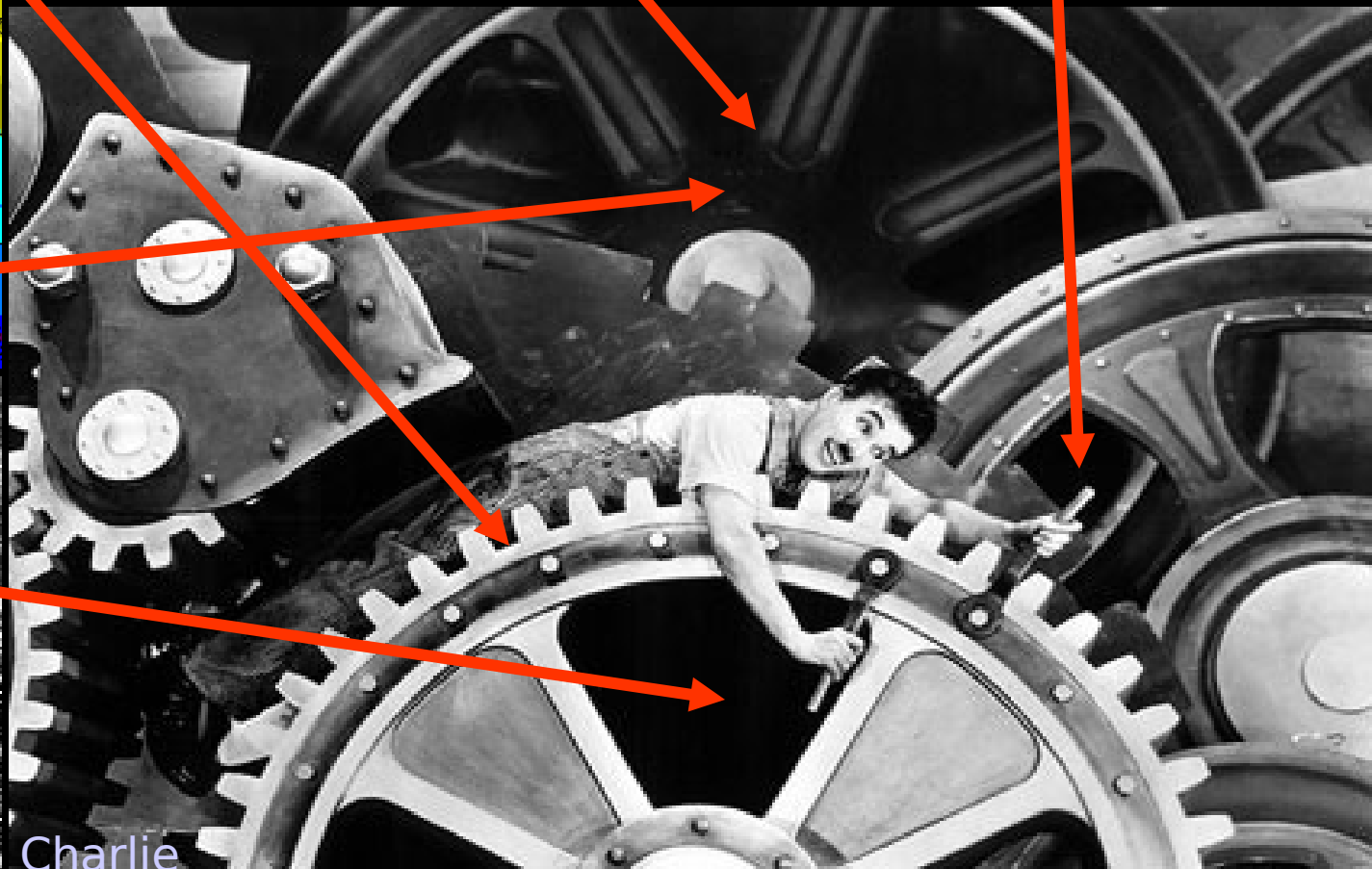




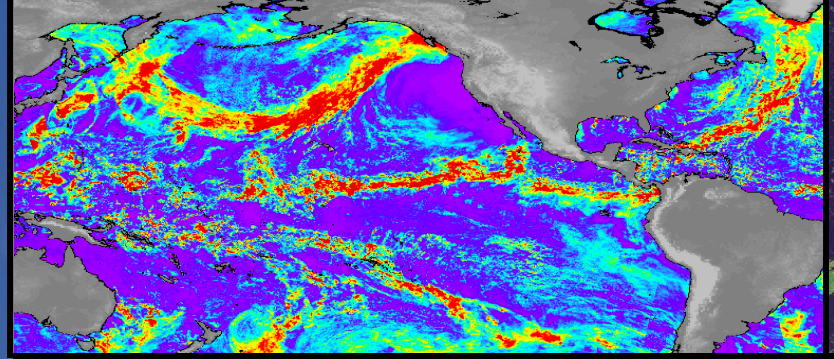
Data Assimilation Machine

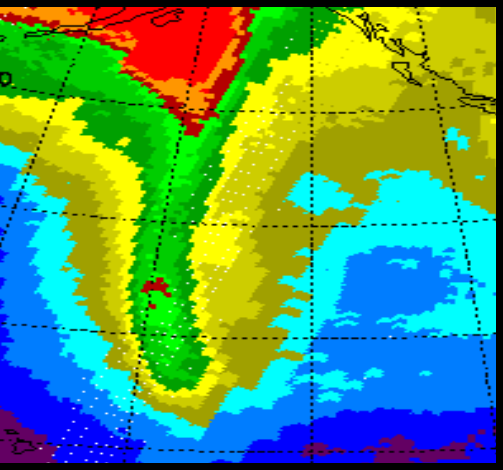


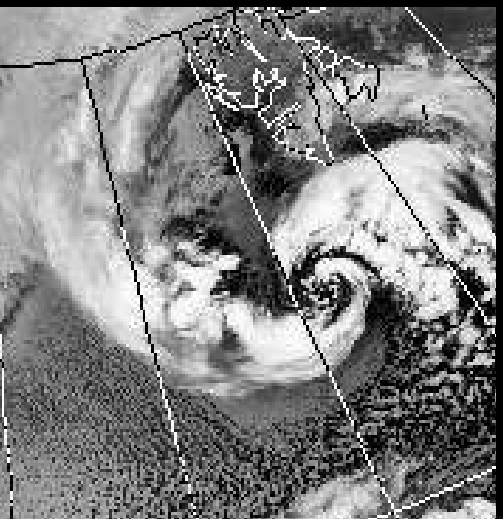




Charlie







Data assimilation utilises the laws governing atmospheric and oceanic motion, thermodynamics, and composition to integrate diverse observations for monitoring and prediction of the Earth System.

REQUIREMENTS

- **Dedicated High-Performance Computer Facilities** with capacities 10,000-times that of today linked to a global network of research, forecast and early-warning centres”
- **Research** to improve the performance and application of forecast models and user products
- **Maintaining and Enhancing Observing Systems** to support present and future prediction, monitoring and early-warning systems
- **Information Communication Systems** with rapid high-band-width data access and visualization of weather, climate events, forecasts, warnings and impacts
- **National and International Support** for the ***Project*** *development and implementation*

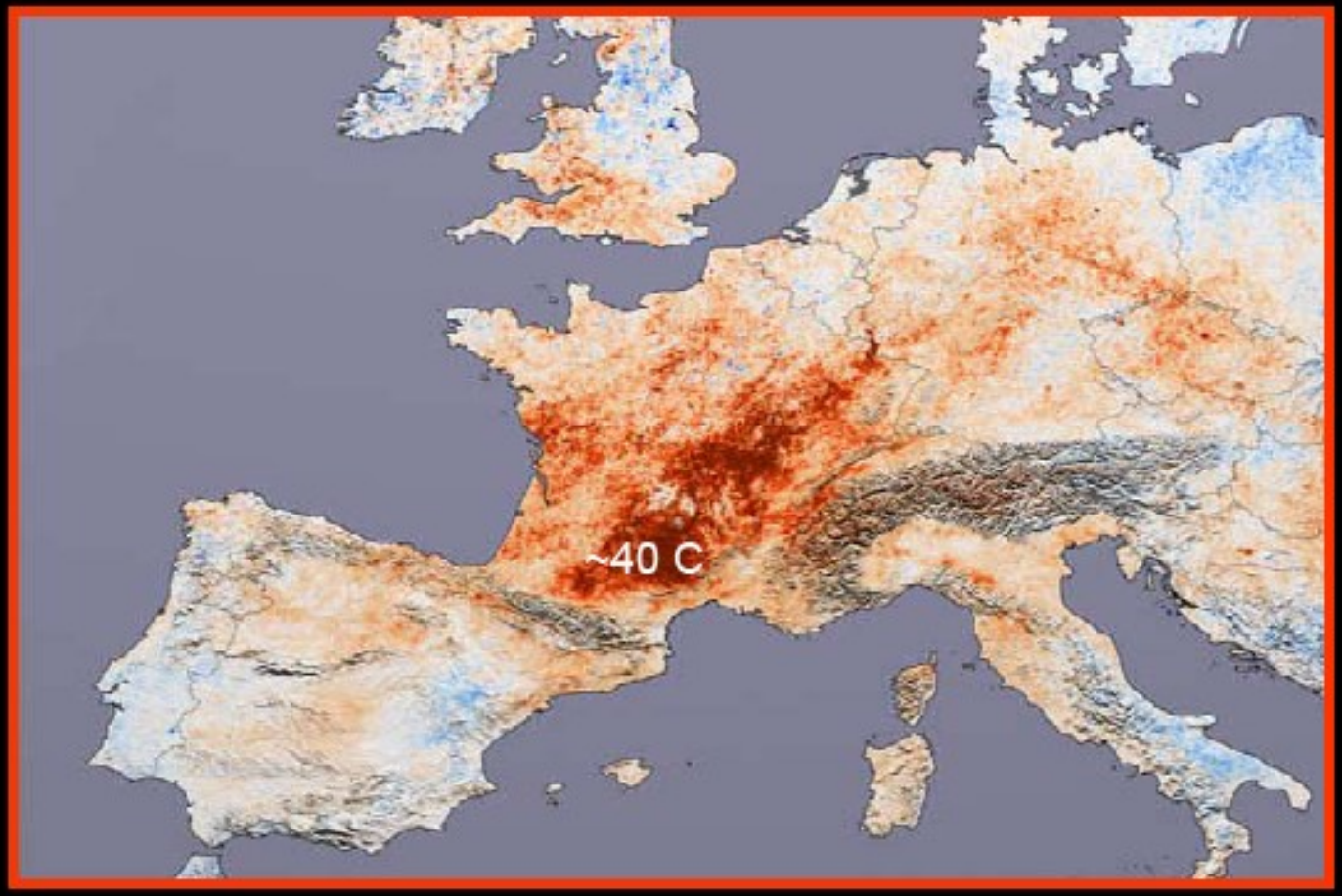
Project Outcomes Will Include:

Projections of the Frequency and Intensity of Extreme Weather Events in a Changing Climate

Tropical Cyclones Winter Storms Floods Heat Waves

The Extreme Heat Wave of August 2003

A record heat wave scorched Europe in August 2003, claiming an estimated 35,000 lives. In France alone, 14,802 people died from the searing. In the worst heat spell in decades, temperatures in France soared to 104 degrees Fahrenheit (40 degrees Celsius) and remained unusually high for two weeks.



Surface Temperature

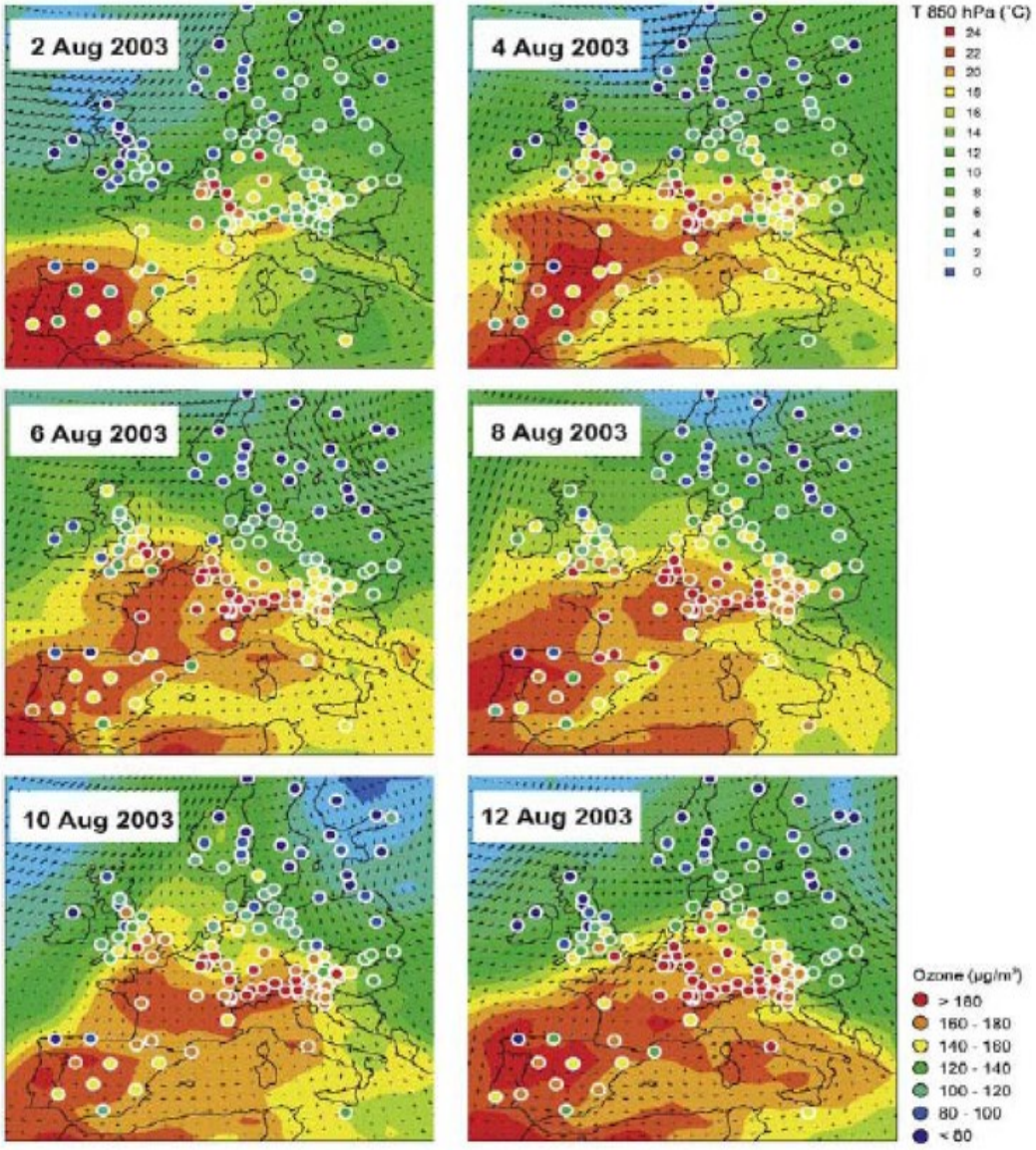
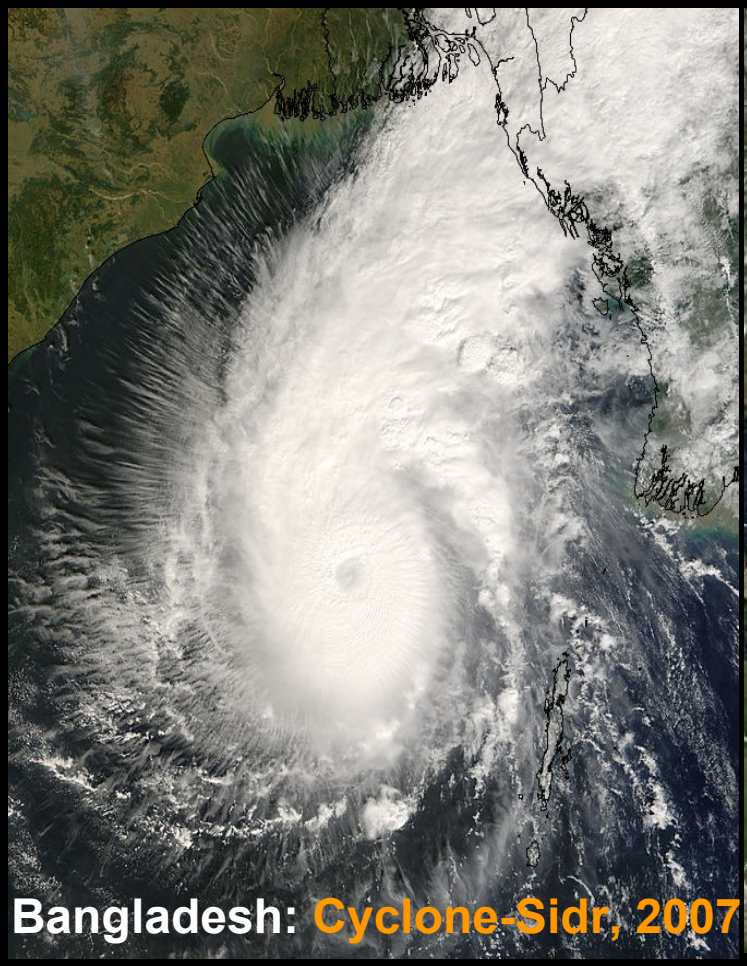


Figure 7. The daily maximum ozone concentrations (solid circles) on top of the temperature on the 850 hPa surface (°C) and the wind at the same level during the August 2003 episode.

Maximum Daily Ozone Concentration:
red dots
180 pphm/vol**EXTREME**

50 - 99
Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart/lung disorders at greater risk; damage to some plants.
100 or over
Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage.
850 mbTemperature, shaded

Projections of the Frequency and Intensity of Extreme Weather Events in a Changing Climate



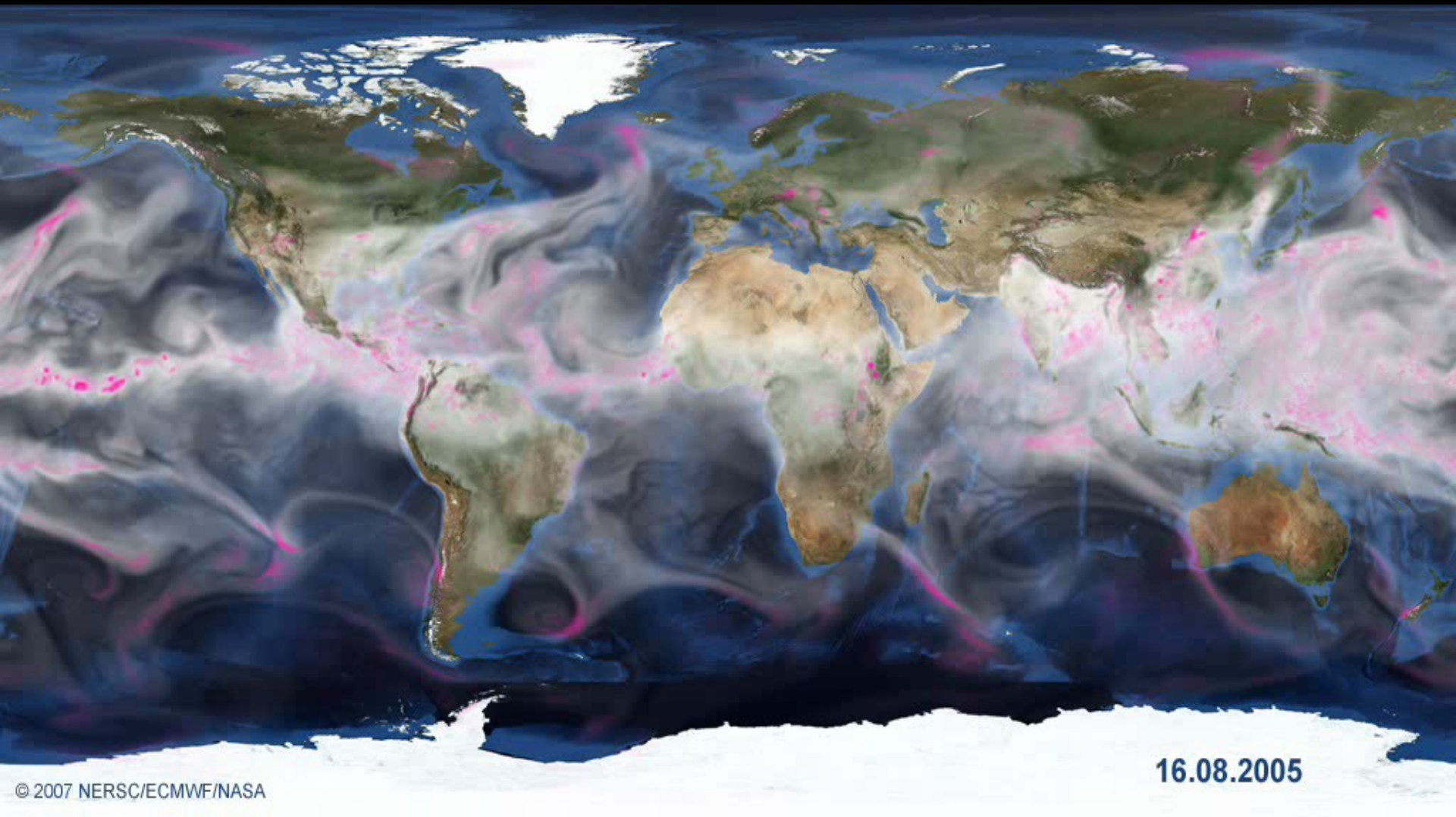
Bangladesh: Cyclone-Sidr, 2007

USA: Hurricane Katrina, 2005

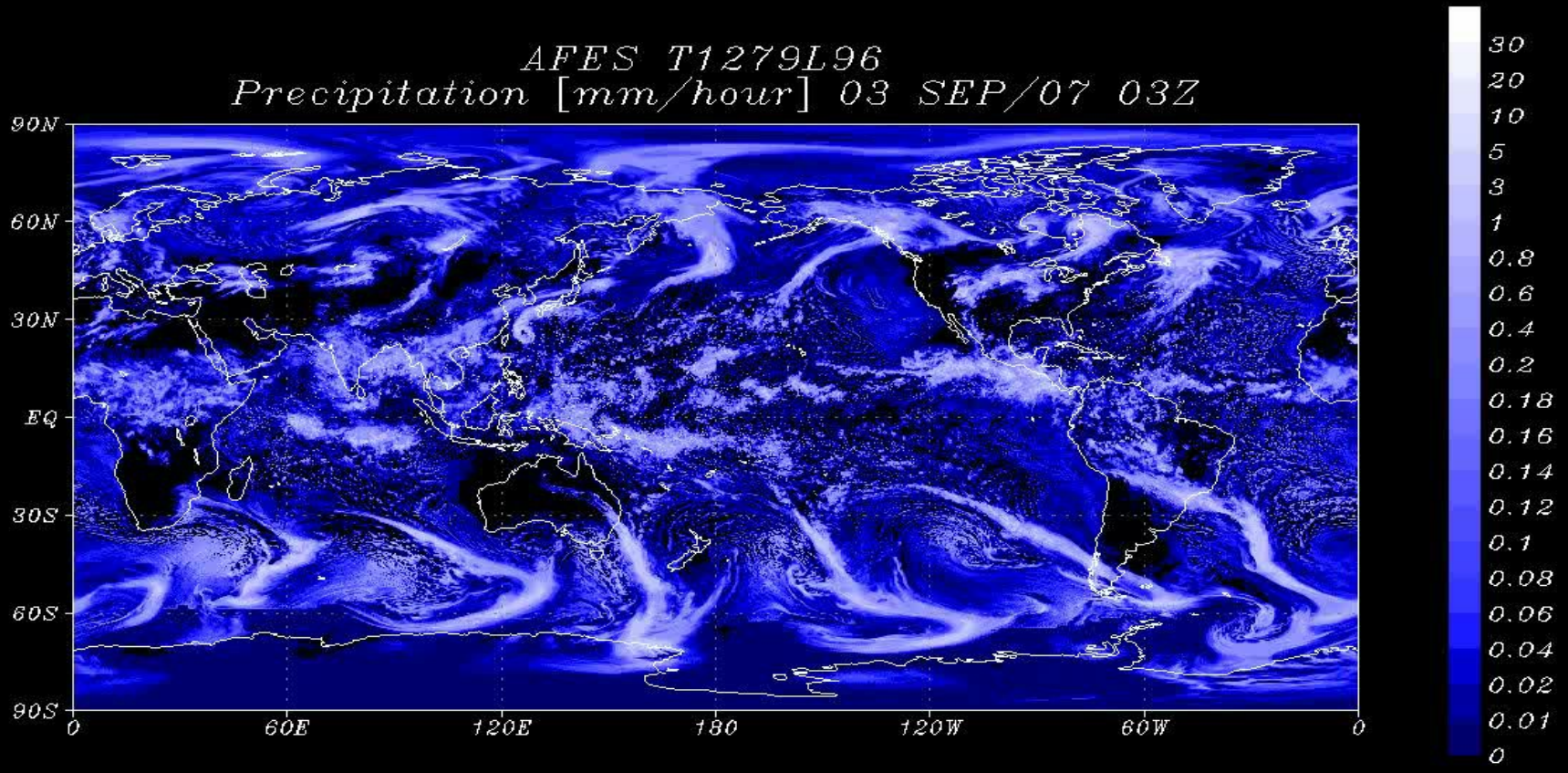
Tropical Cyclones Winter Storms Floods Heat Waves

European Centre for Medium-range Weather Forecasts:

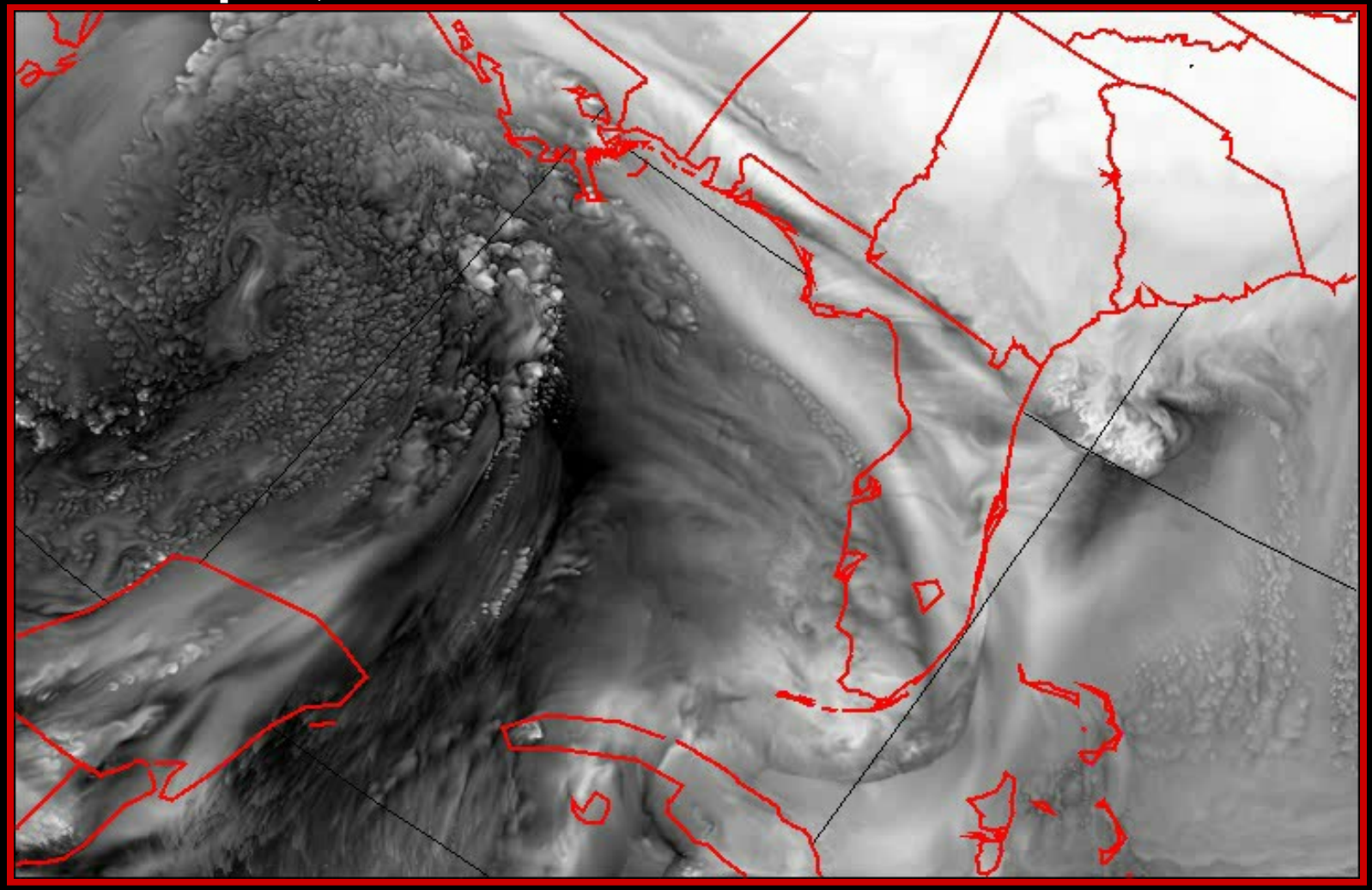
Water-vapor analysis at ~25-km resolution, 16 July-30 November 2005



10-Day time-slice simulation at 10-km resolution from The Earth Simulator Center and Frontier Research Systems for Global Change



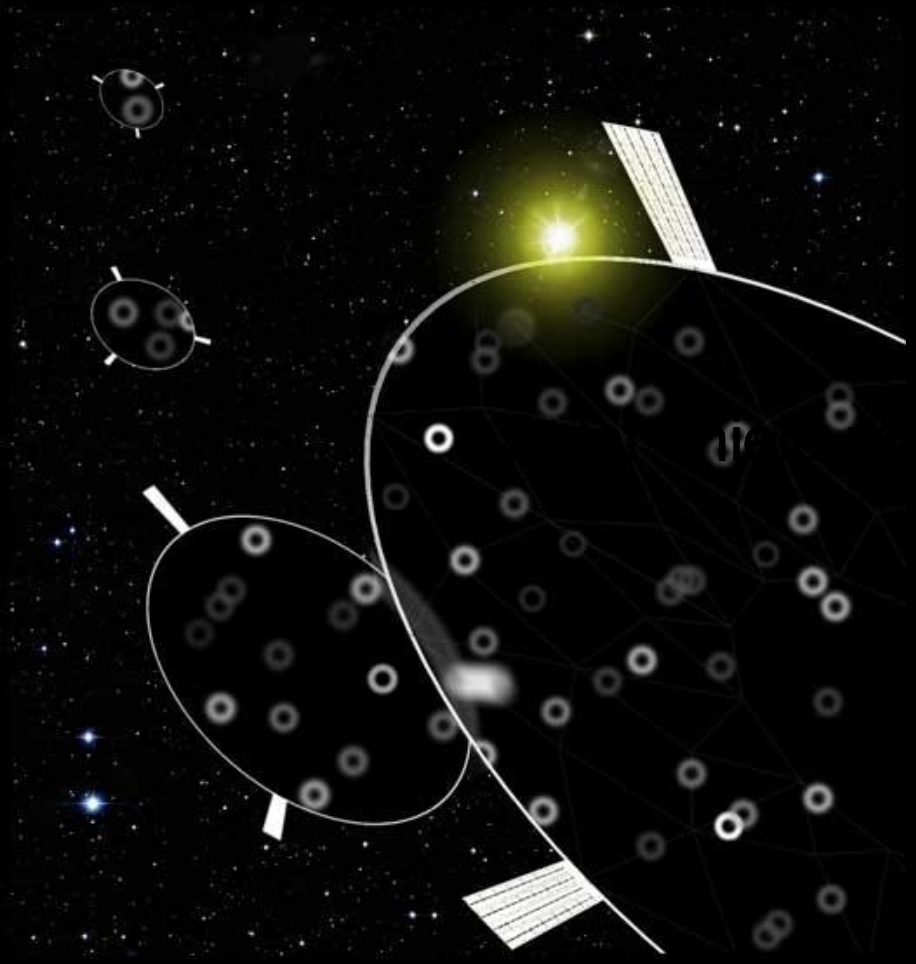
12-h development of Hurricane Earl:
Sept.1, 1998: 1-km horizontal resolution



The LACES Project
Large Atmospheric Computation on the Earth Simulator

Early-Warning Systems to Reduce Vulnerability to famine, drought pestilence and disease

Impact Assessments of proposed geo-engineering interventions to counter global warming



Solar shield may save the planet
Roger Angel

Albedo enhancement by stratospheric sulfur injections Paul Crutzen

Delivering the benefits will require:

- **Building upon** WCC3 and possibly **GEO or other organisations,** as a framework to coordinate the ***Project*** across the weather, climate, Earth-system, natural hazards and socio-economic disciplines

- **Implementing GEO Work Plan Task CL-07-01:** "Seamless Weather and Climate Prediction System"

This effort will require unprecedented international collaboration, as no single nation possesses the scientific capacity and infrastructure to meet the challenge.

Licence / License