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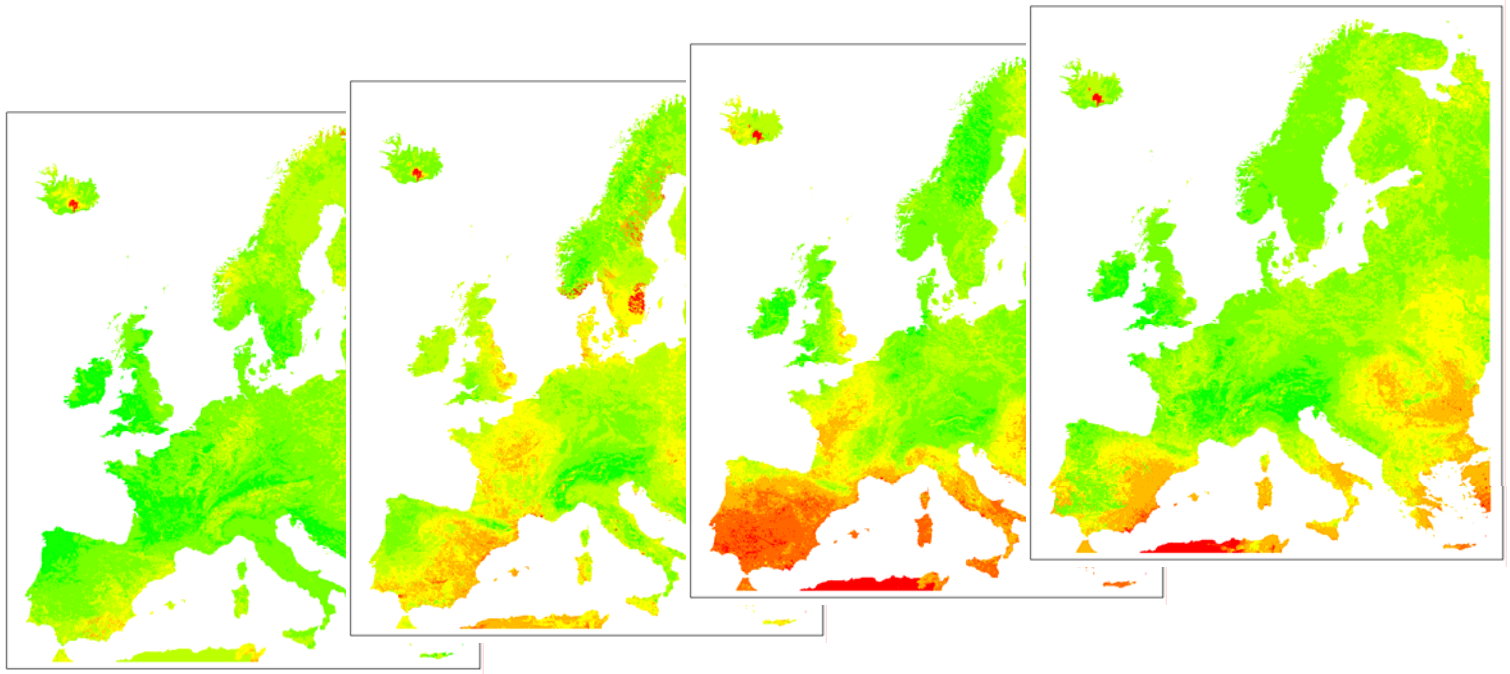
Towards Drought Simulation on the European Scale: Experiences with ERA40-driven LISFLOOD Modelling Results

Stefan Niemeyer, Giovanni Laguardia, Katalin Bodis, Ben Gouweleeuw



Cyprus Conference “Coping with Drought and Water Deficiency:
From Research to Policy Making”
Cyprus, 12./13. May 2005

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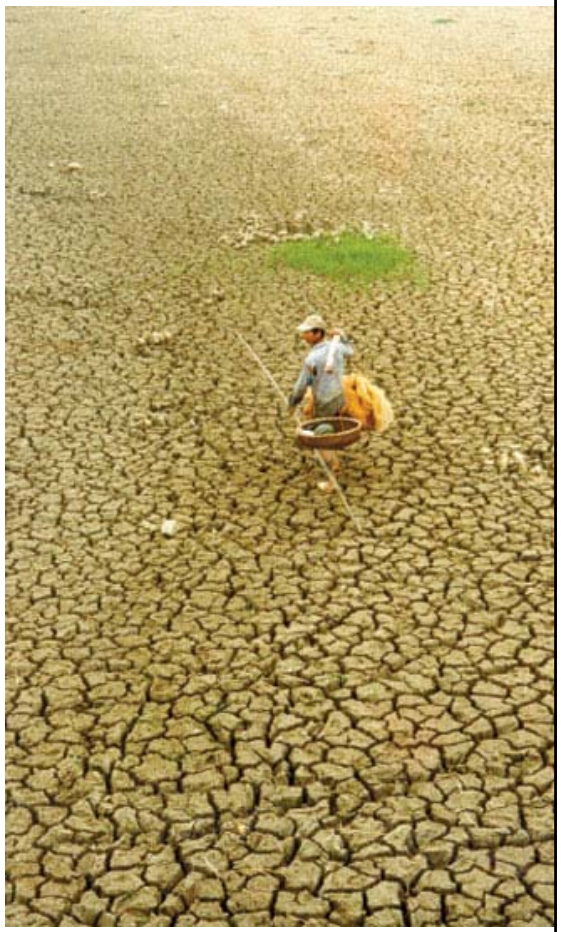
Objectives

- Feasibility study of LISFLOOD hydrological model and EFAS infrastructure for drought simulation and forecasting:
  - **Soil water availability**
  - Low flows
  - Plant water stress
  - Water availability in reservoirs & lakes
  - Groundwater resources

- Vision of a European Drought Alert System (EDAS)
  - analogous to European Flood Alert System
  - using medium-range weather forecasts (3-14 d)
  - using monthly and seasonal forecast products



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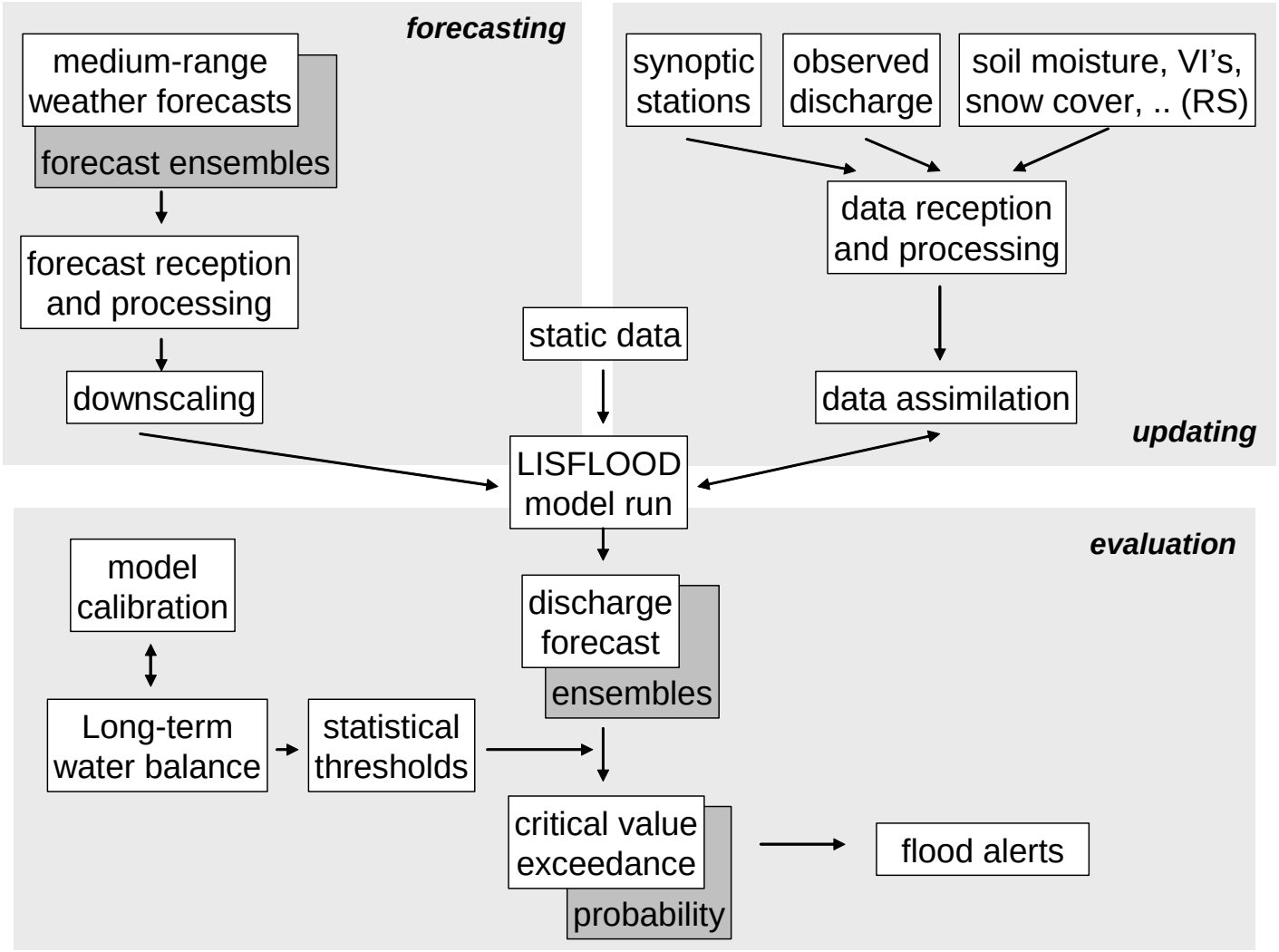
European Flood Alert System



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European Flood Alert System

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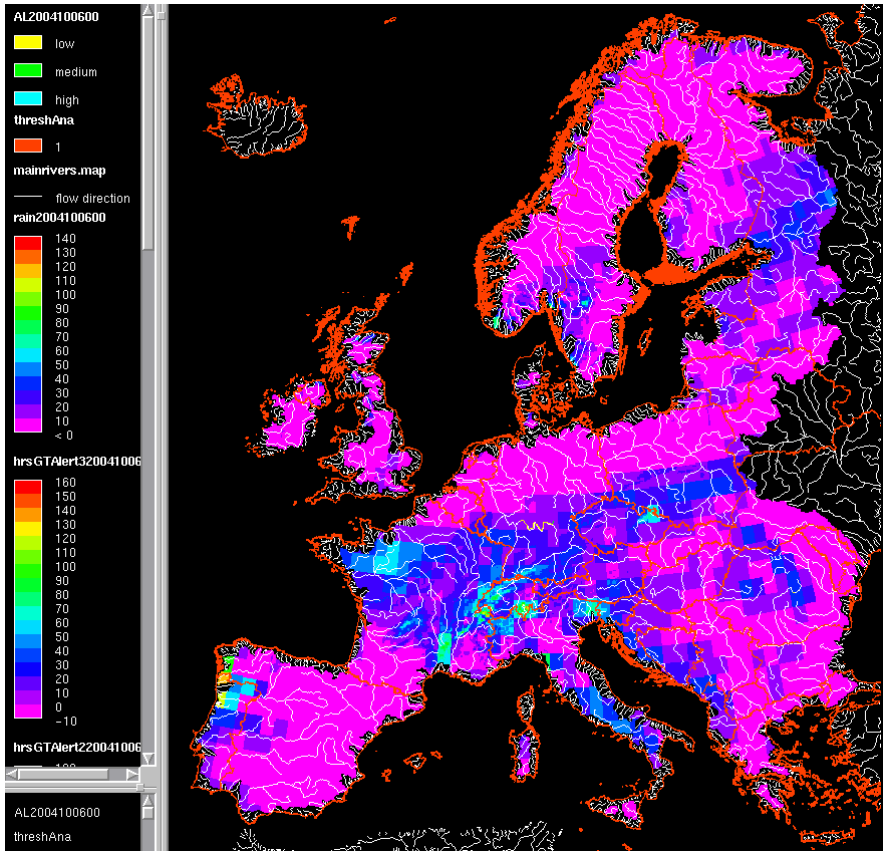
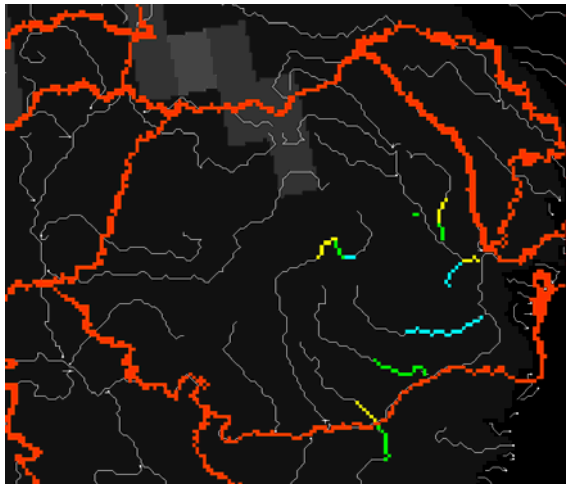
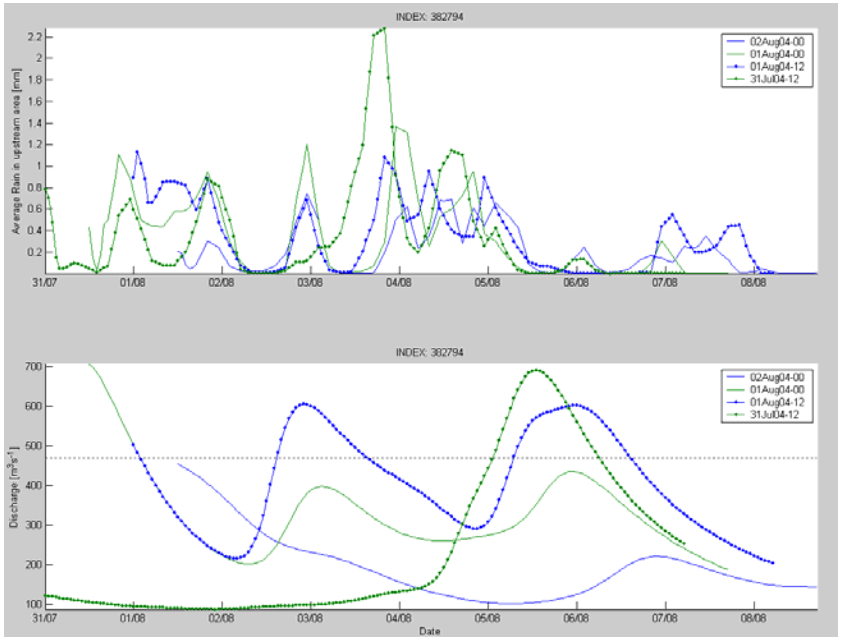






LISFLOOD model

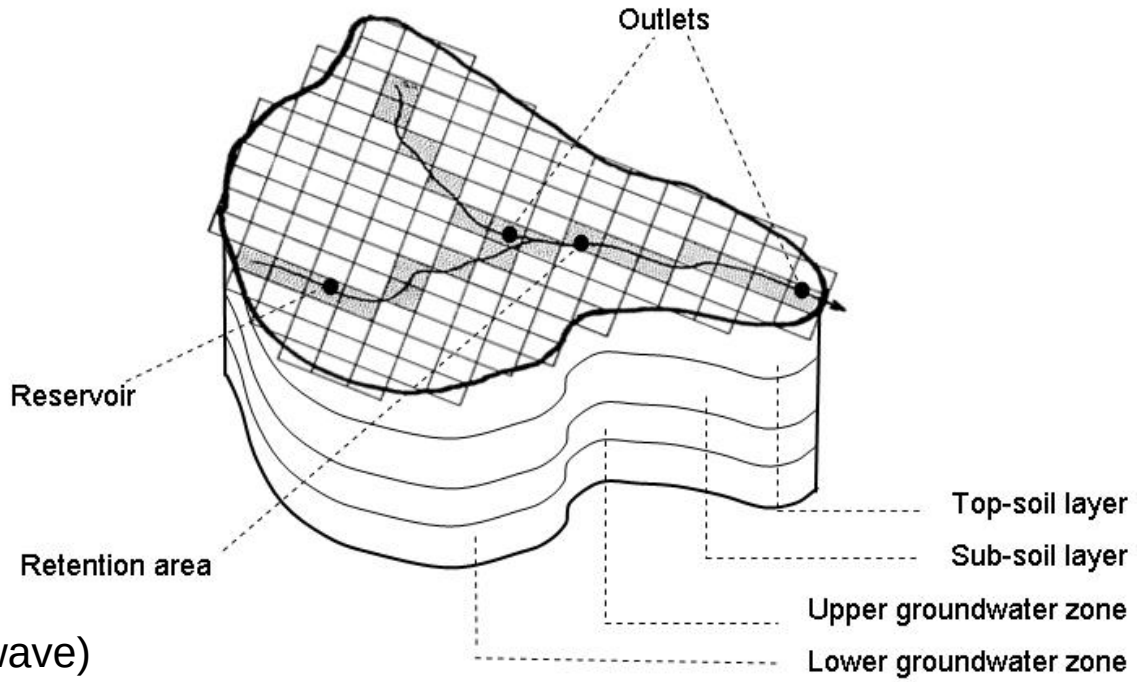
A physically based distributed rainfall-runoff model programmed in a dynamic GIS-language

- Division Rainfall/Snow
- Interception
- Evapotranspiration
- Leaf drainage

- Snow melt
- Glacier melt
- *Soil water processes*
- Groundwater flow

- River channel flow (kinematic and diffusion wave)

- Reservoir operations
- Retention storage / polders
- Lakes
- Dyke breaks (in prep)



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LISFLOOD model

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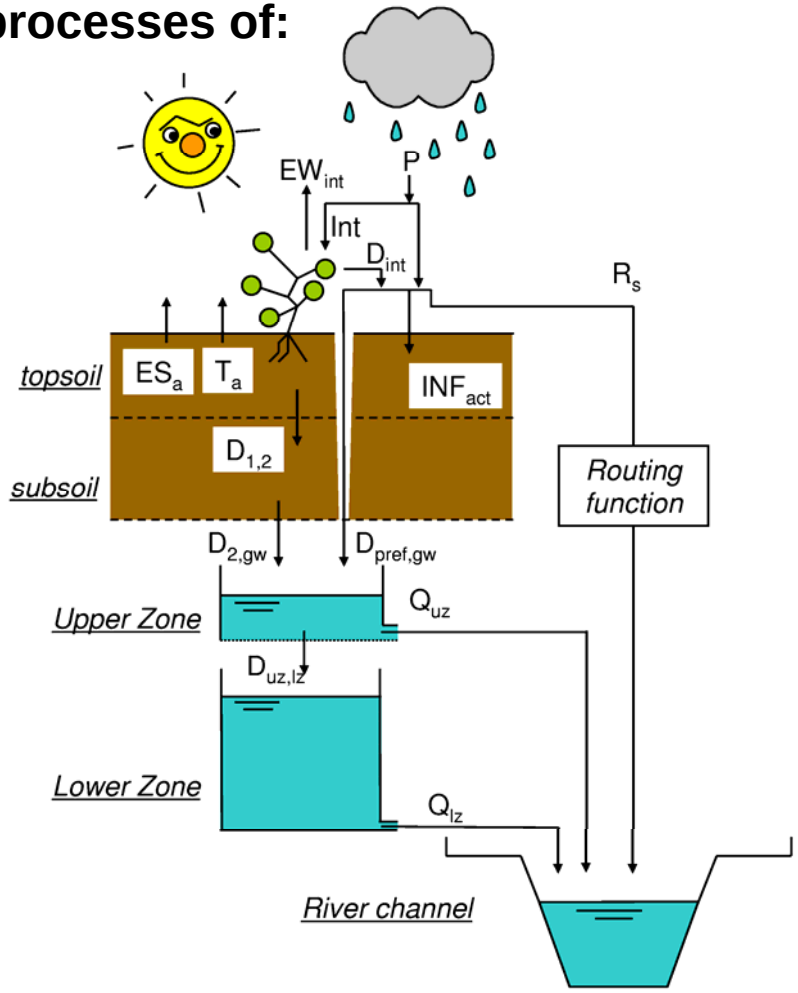
The soil component of LISFLOOD consists of a two-layer soil model describing the processes of:

- Infiltration
- Percolation / vertical soil water redistribution
- Groundwater recharge
- Drainage into river channel / preferential flow
- Soil evaporation
- Plant water uptake
- Soil freezing



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ERA40-driven LISFLOOD simulations

- Describe the spatio-temporal evolution of soil moisture
- Consistent soil processes' description and modelling on the pan-European scale

- Examine and evaluate the representation of soil moisture in the model
- Detect deficiencies and short-comings of the current model version
  - Suggest improvements / corrections / extensions
- Create a pseudo-climatological basis for the evaluation of current and forecasted future soil moisture values

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ERA40

- Prepared and distributed by the European Centre of Medium-Range Weather Forecasts (ECMWF)
- Re-analysis dataset of meteorological forecast data
  - Re-processed forecast data, taking into account consistent and most up-to-date data assimilation techniques
- Comprises the period 1958 – 2001
- Full resolution surface analysis and surface forecast products used
- Re-sampled to a daily temporal resolution
- Re-sampled to a 5 km spatial resolution

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Method (1)

- LISFLOOD model set-up as currently used for the pre-operational European Flood Alert System (EFAS)
  - Using European Soil Map 1:1 Mio. plus additional soil data, where available
  - Using CORINE land cover information
  - Simulations currently limited to EFAS modelling extent
- 44 years of continuous simulations
  - Initialization with default values for 1.1.1958, and re-run after one year with simulated results
- Conversion of soil moisture maps into soil suction (pF)
  - Allows for the comparison among different soil types

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Method (2)

- Generalization by spatial averaging over NUTS3 regions
  - Accounts for uncertainty of input maps
  - Allows for the comparison of regional patterns rather than single locations
  - Integrated information usually required by the Commission
- Normalization of soil suction values by 44-year average and standard deviation
  - Allows for the comparison of different regions

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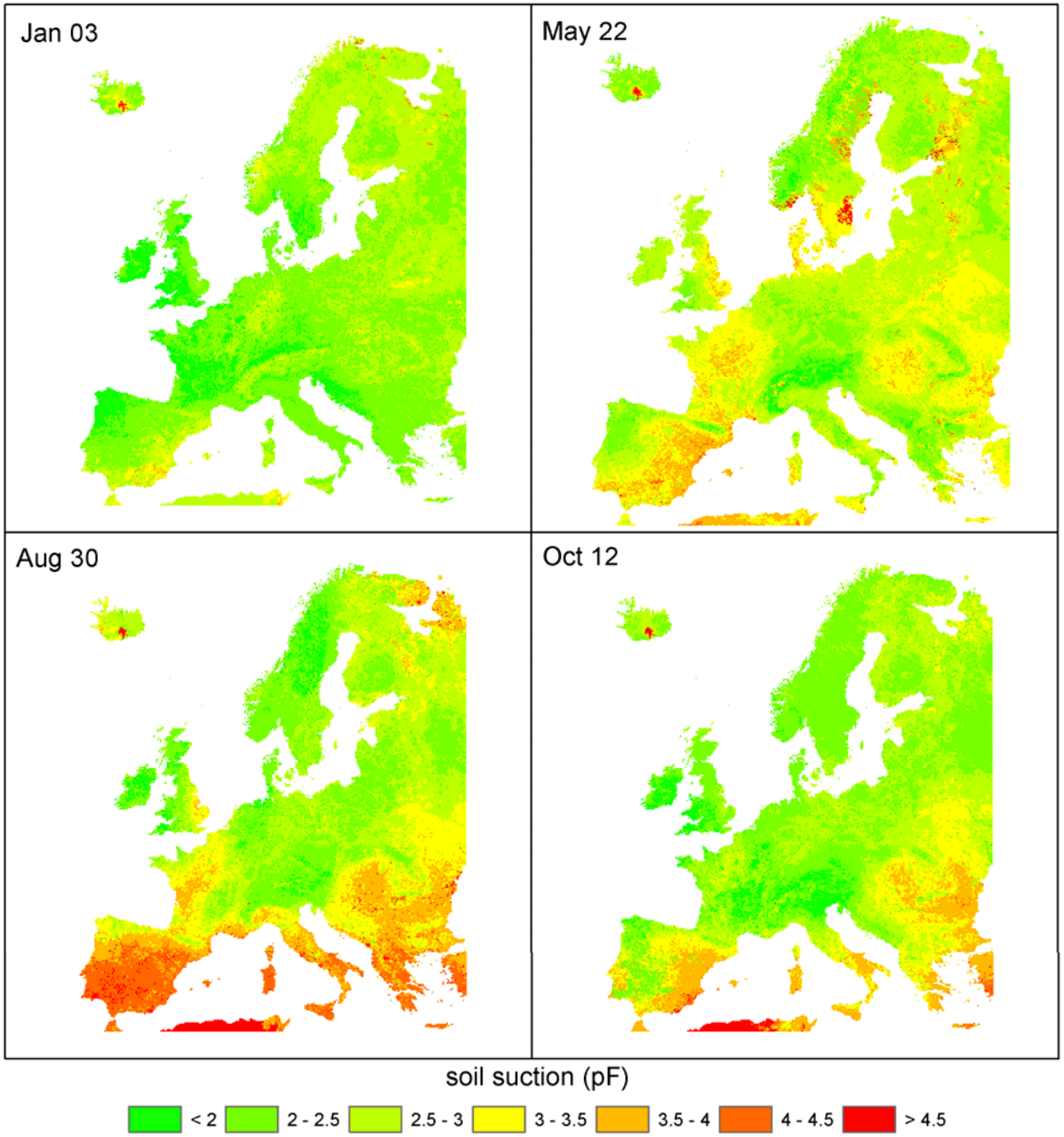
Results (1)

- Example year 1960
- Original 5 km resolution
- Daily maps of pF
- 1.8 <= pF <= 4.2
  (wet) (dry)



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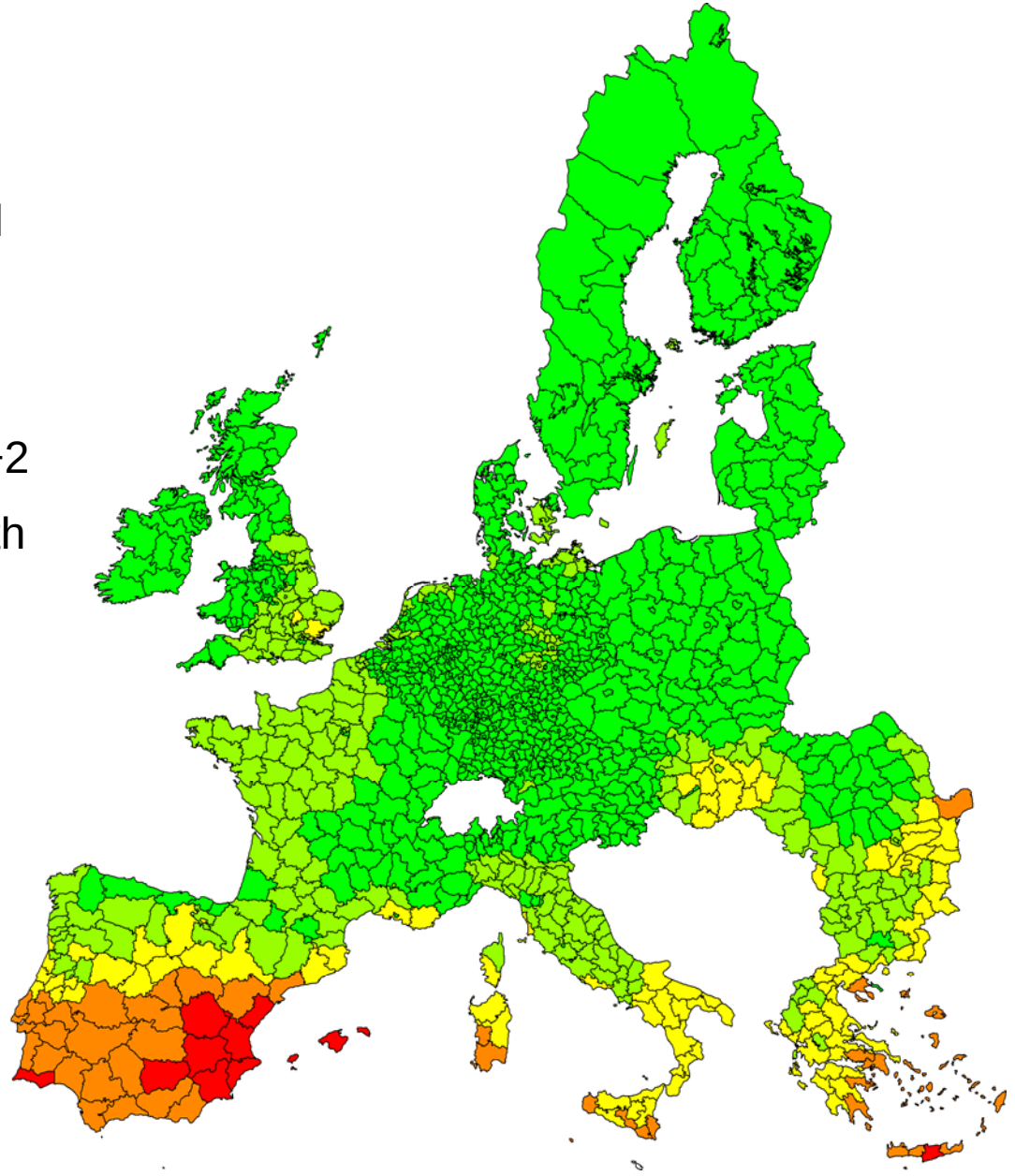
Results (2)

- Example regional averaging
- Averaged over GISCO NUTS3 regions of EU25+2
- No. days/year with pF > 3.0



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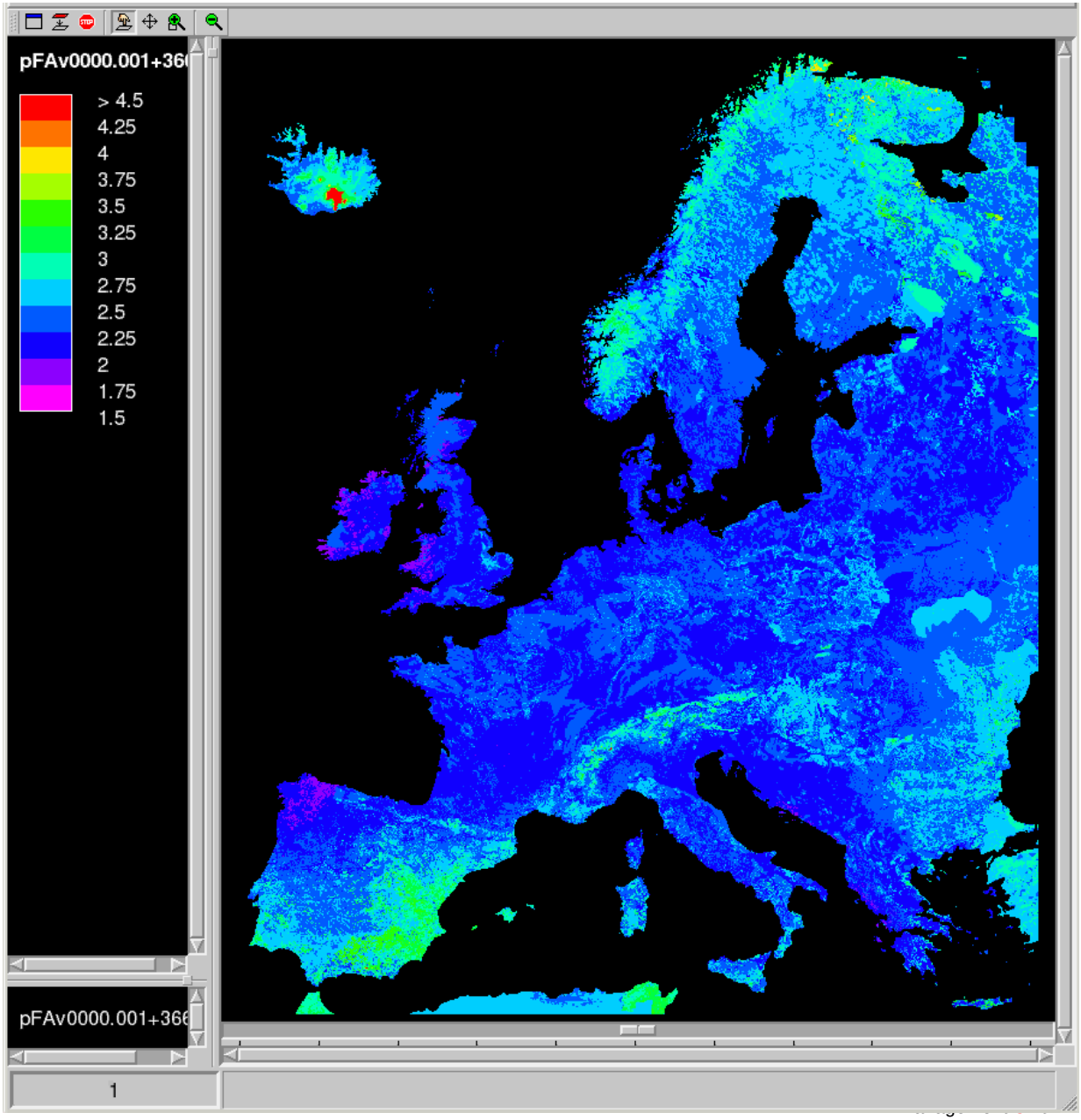
Results (4)

- 44-year daily average values
- 1.8 <= pF <= 4.2
  (wet) (dry)



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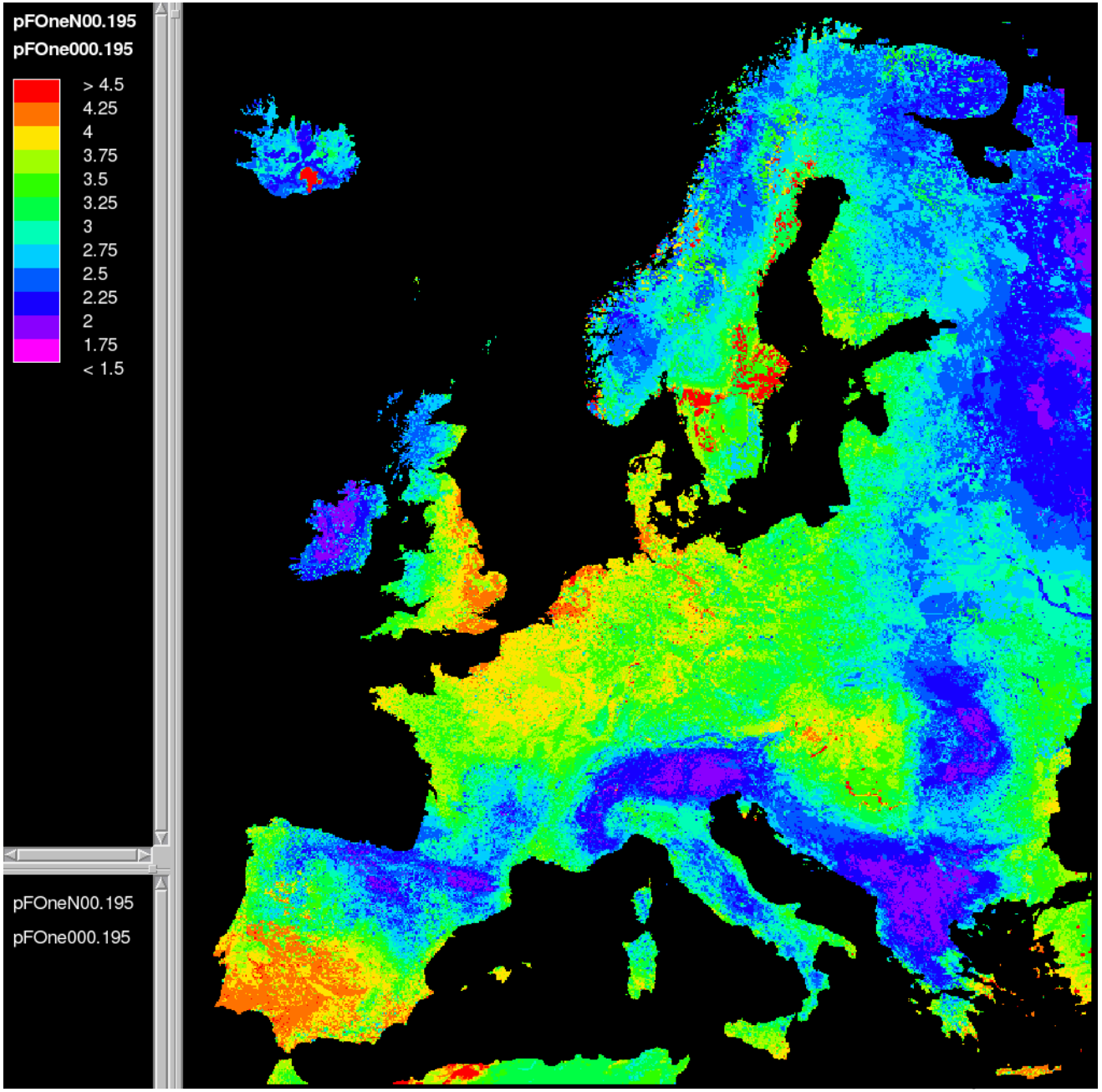
Results (5)

- image of July 15, 1976 (hot summer in NW Europe!)
- original 5 km resolution

- Dry in ES, UK, NL, FR, DE
- Wet in Alps, Balkans, IT, RO
- Erroneous values in IS, SE



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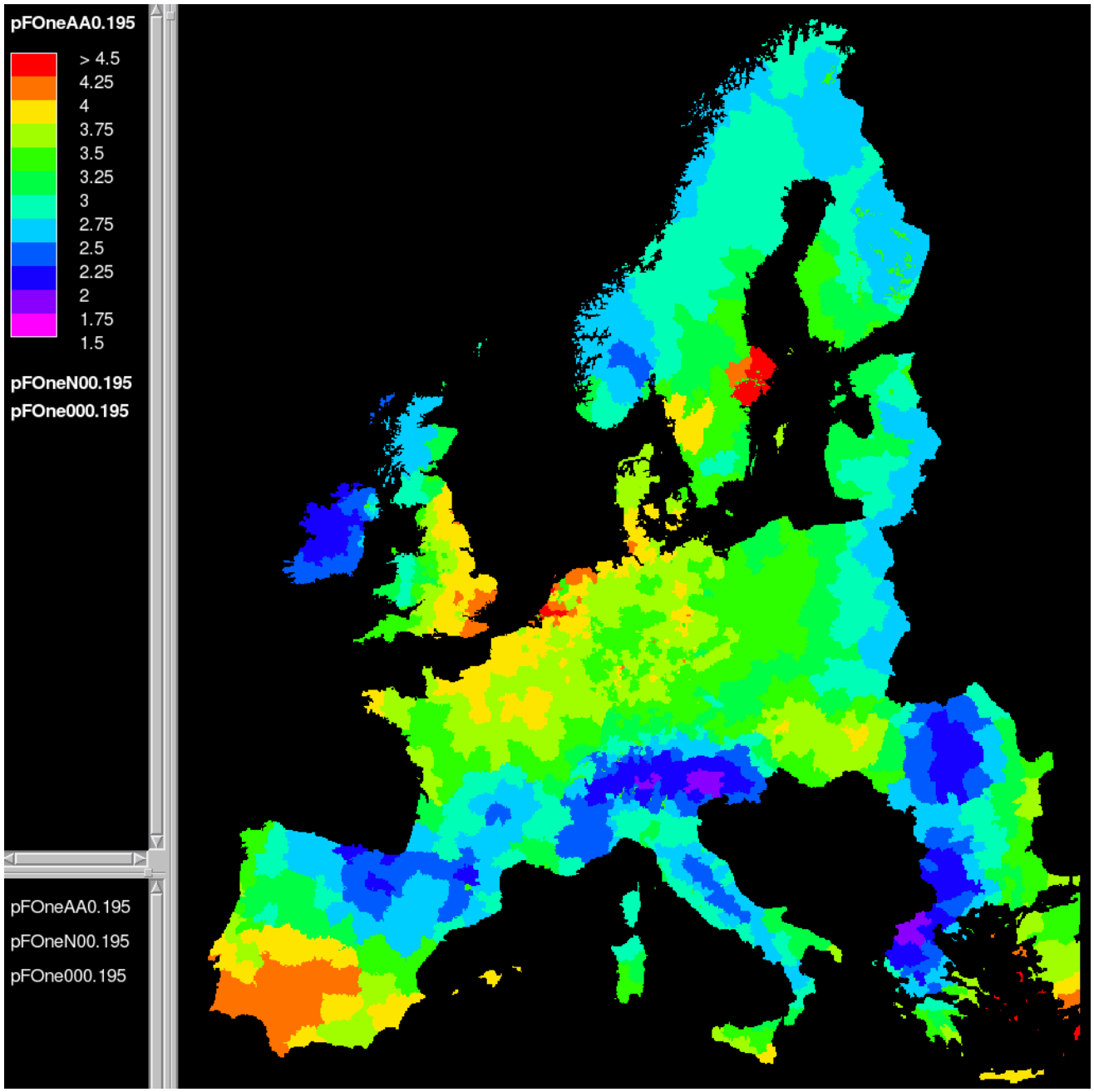
Results (6)

- July 15, 1976
- Spatially averaged pF values
- Patterns of dry/wet distribution well visible



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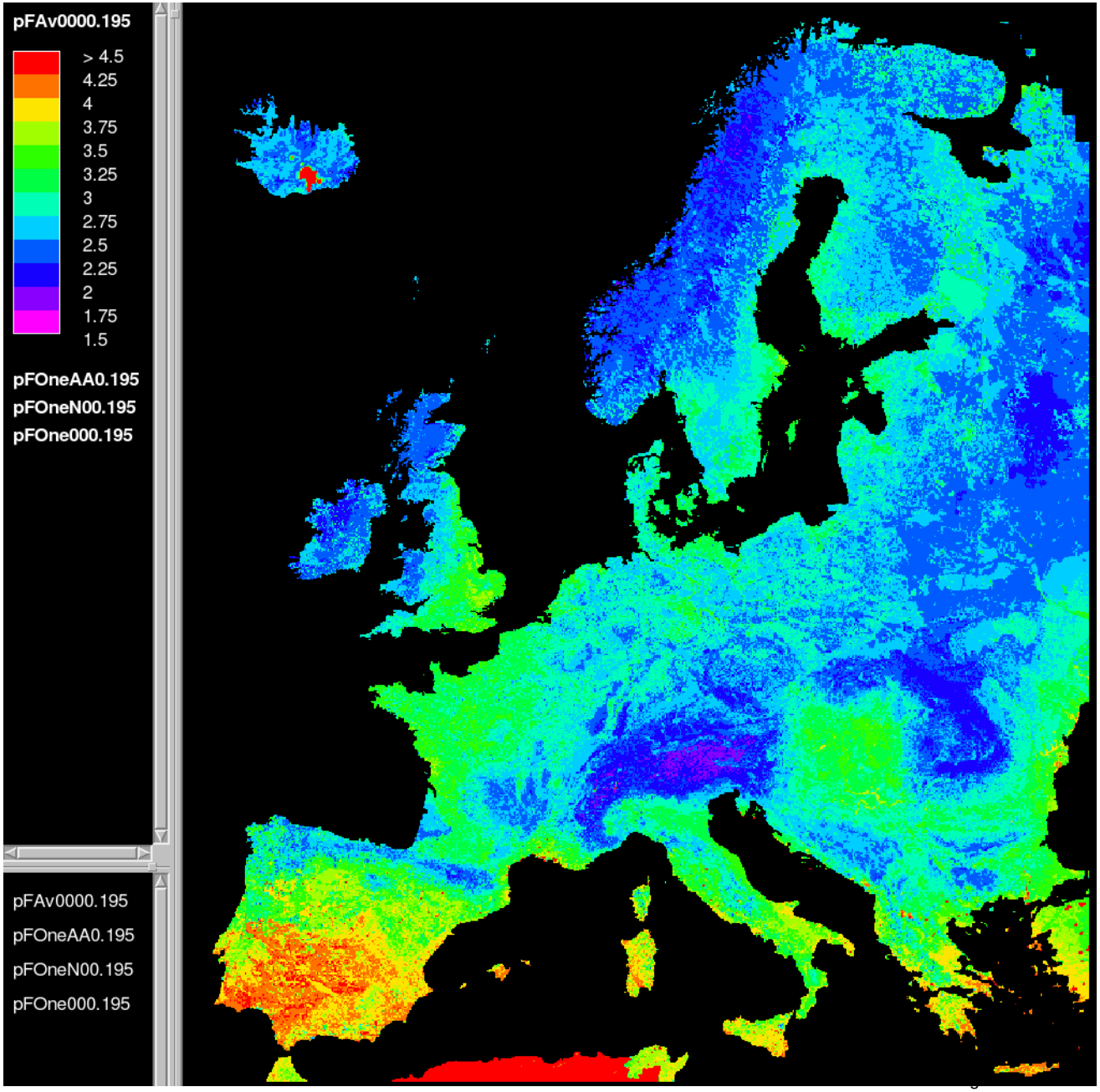
Results (7)

- July 15
- 5 km spatial resolution
- Averaged over period 1958-2001

- Pseudo-climatological soil moisture distribution



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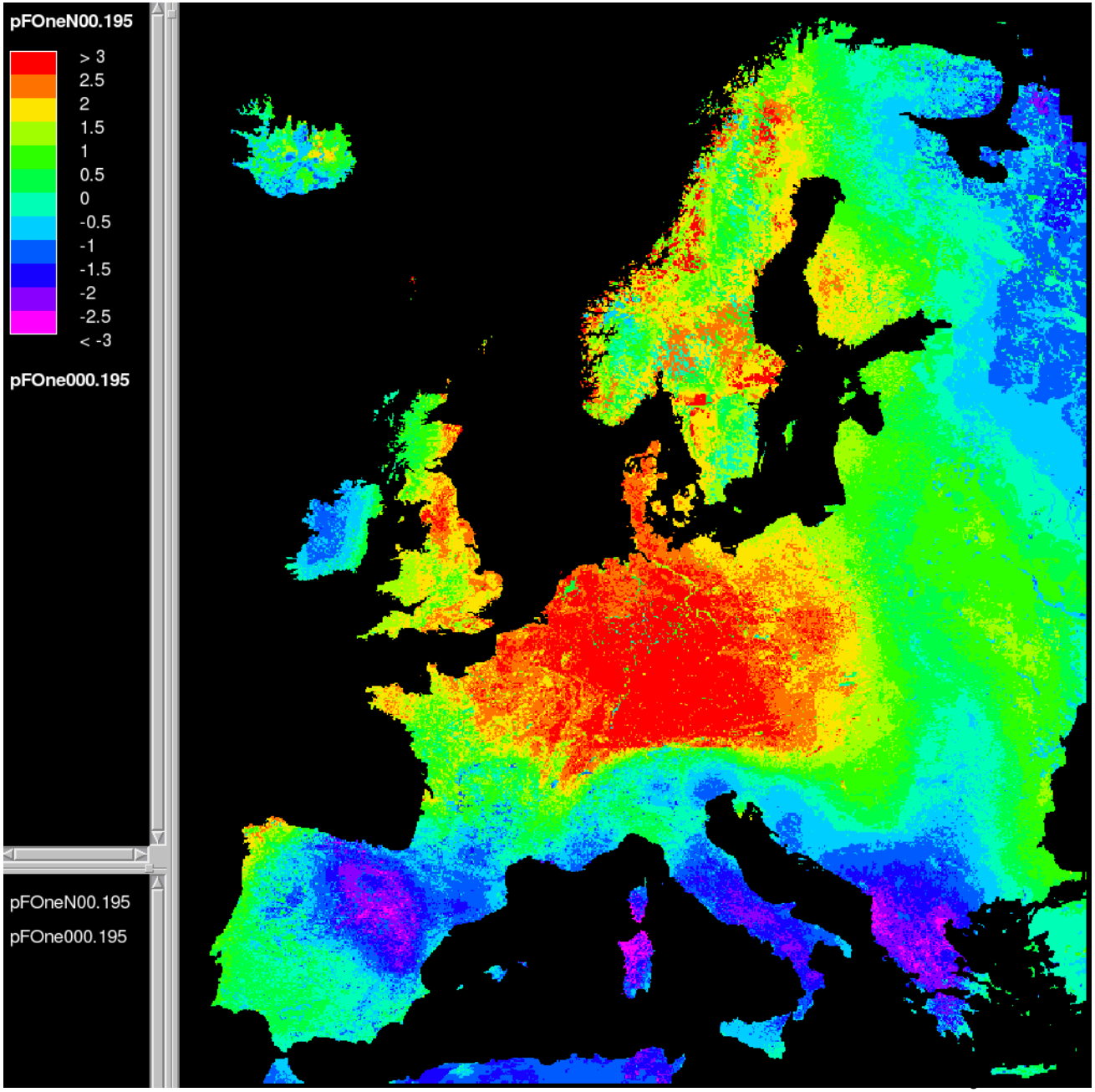
Results (8)

- July 15, 1976
- 5 km spatial resolution
- Normalized soil moisture
- < 0 = wet
  > 0 = dry
  > 2 = very dry!
- Very dry conditions in north FR, NL, BE, DE, PL, UK
- Very wet in the Mediterranean



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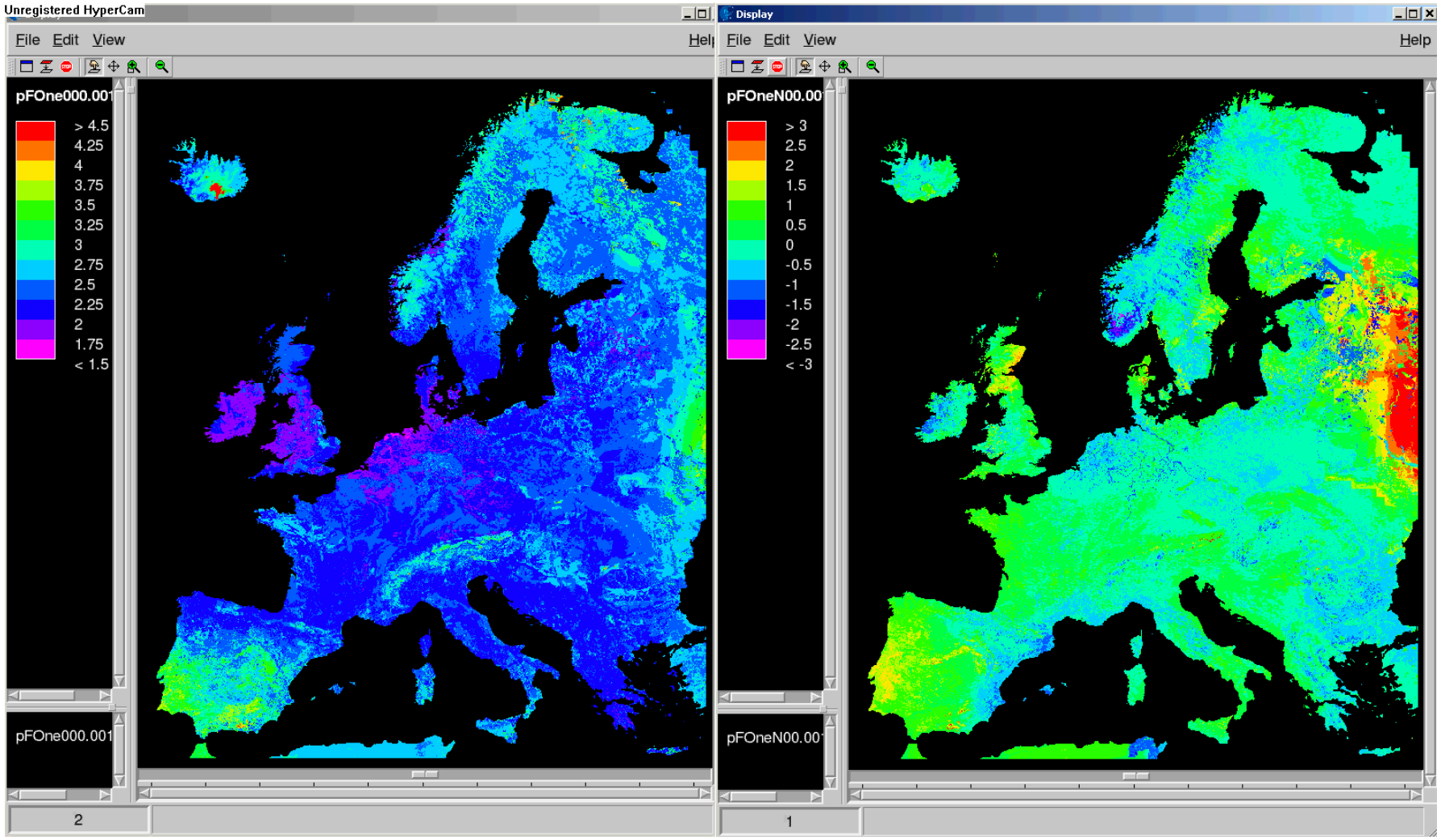
Results (9)

- Comparison of daily original and normalized pF values for 1976 (very hot summer!)



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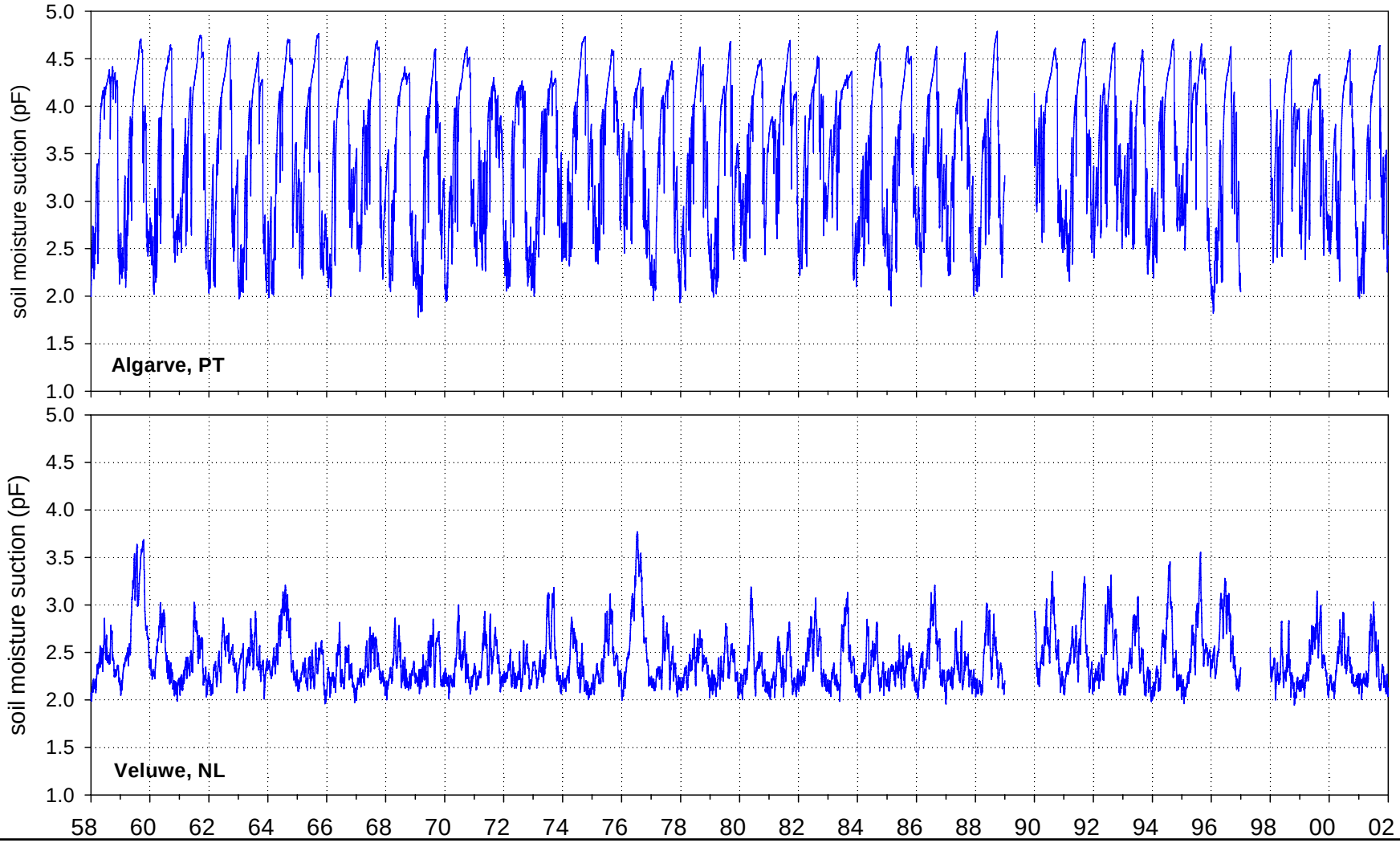
Results (10)

- pF values for two regions in PT, NL for the period 1958 – 2001



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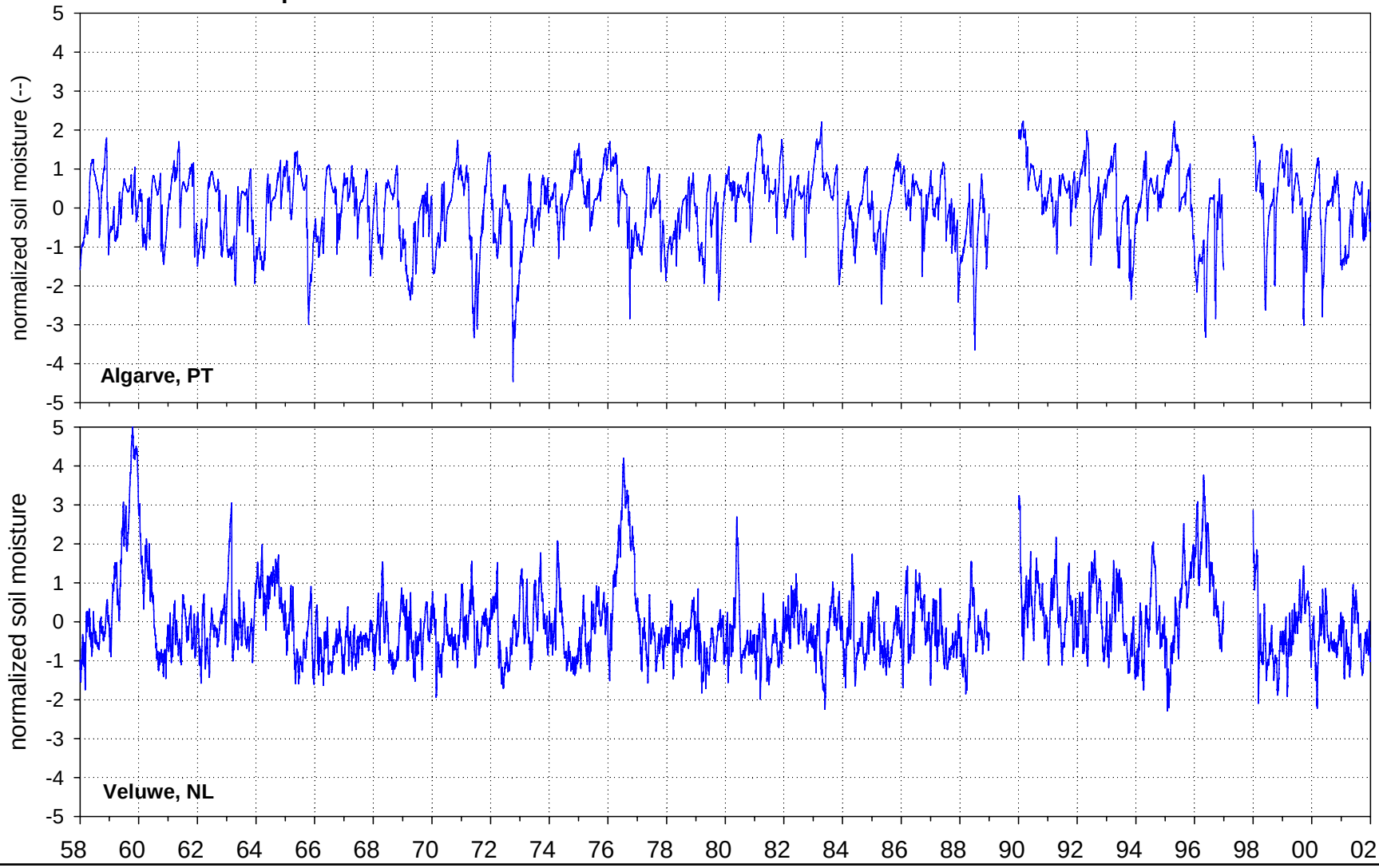
Results (11)

- Normalized pF values for two regions in PT, NL for the period 1958 – 2001



Feasibility Study Droughts

Validation

- Comparison with independent products on top-soil moisture conditions
  - **NOAA SSM/I wetness products**
    - Available for 1988 – 2003, weekly resolution
    - ca. 30 km spatial resolution
  - **Global Soil Moisture Archive** derived from ESA ERS scatterometer data
    - Provided by University of Vienna (W. Wagner)
    - 1992 – 2000, monthly resolution
    - ca. 50 km spatial resolution
    - Soil Water Index
  - …

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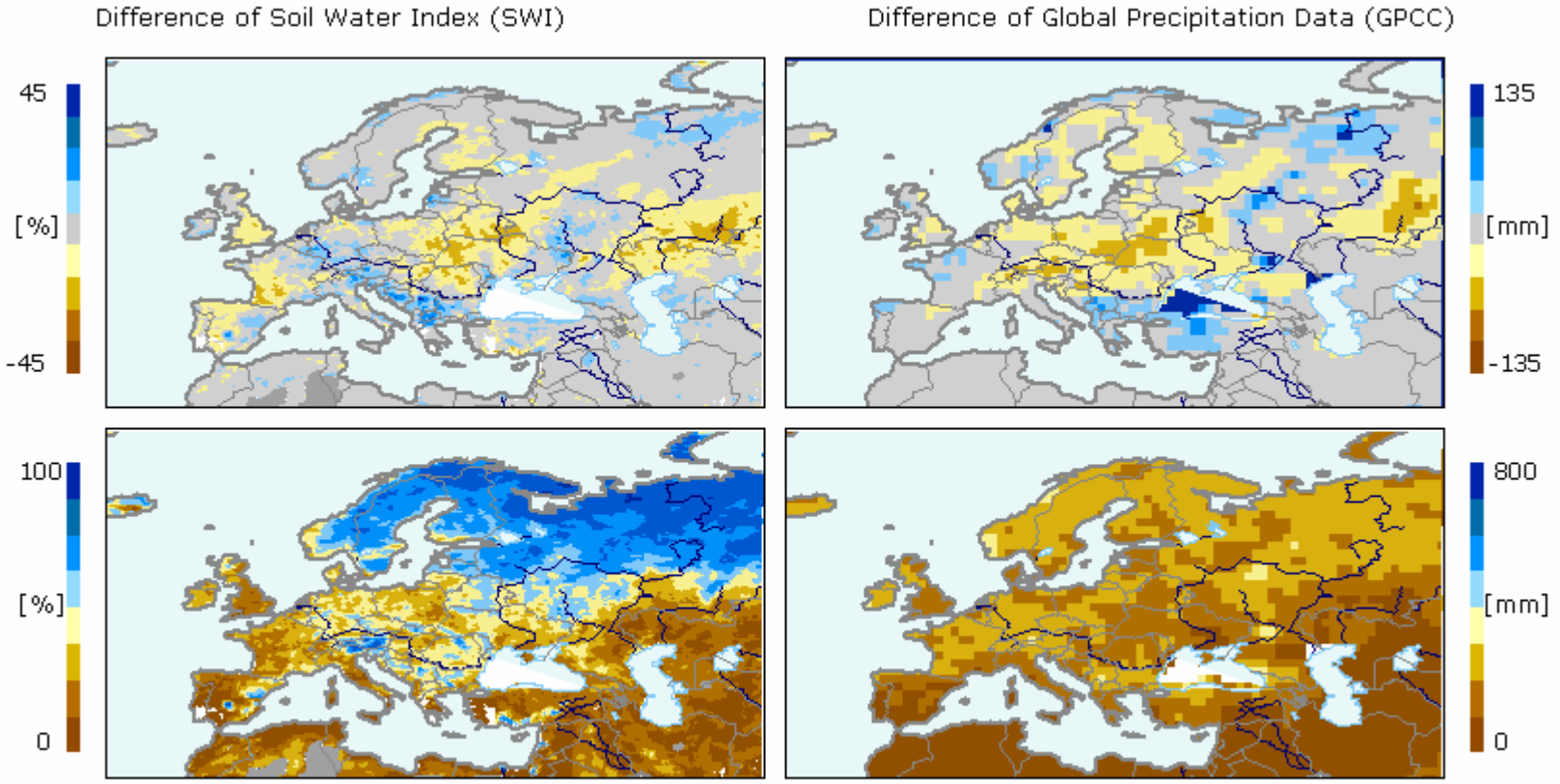
Validation: scatterometer data

Europe: July 1995



Vienna University of Technology, Institute of Photogrammetry and Remote Sensing
Processing Status: April 2002

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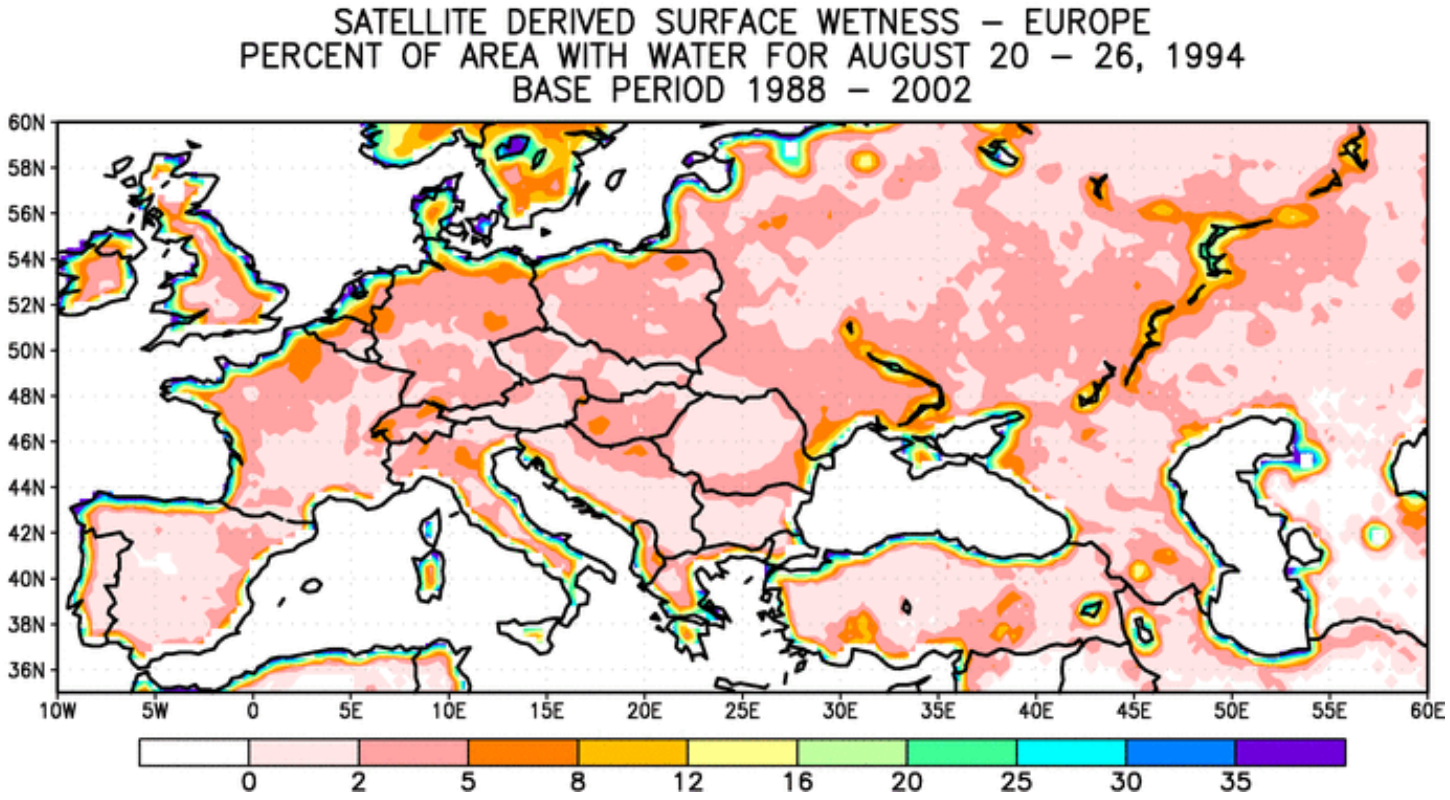
Validation: SSM/1 data



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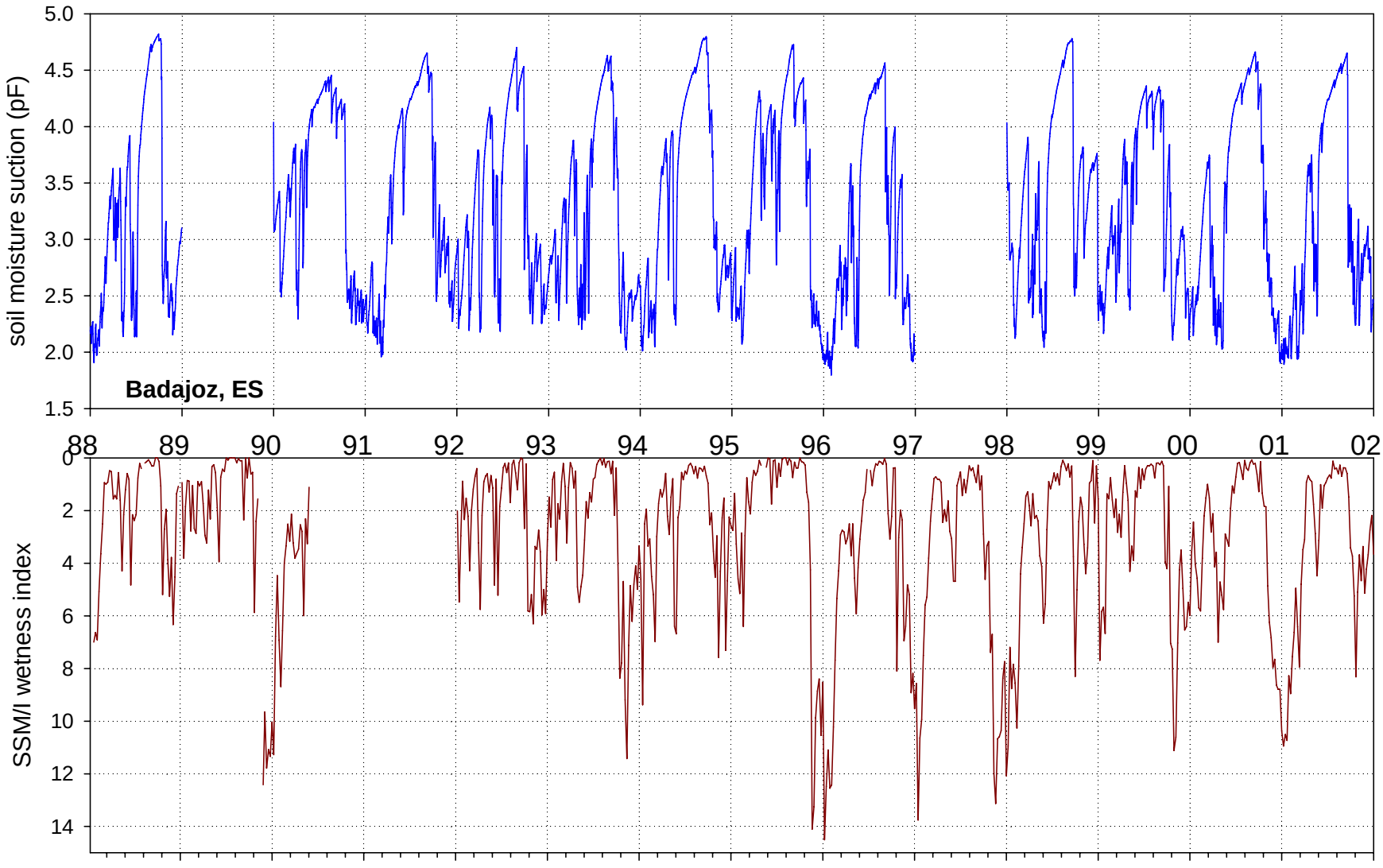
Validation: SSM/1 data



Feasibility Study Droughts

Next Steps

Short-term perspective:

- Validation exercise to be continued…
- Model corrections / extensions
  - Enlarge modelling frame
  - Problems identified in Scandinavia, Iceland
  - Calibration still ongoing for EFAS; benefits for drought applications as well
- Close ‘gap’ between 2001 and today
  - Simulation with JRC-MARS meteorological data (>1980)
  - compare & fit to ERA40-driven simulations
  - Validate with drought event of summer 2003
- Normalize soil moisture maps currently produced by EFAS with computed ERA40 pseudo-climatological values
  - Evaluate current drought situation in Portugal (2004/05)
  - … forecasting soil moisture droughts, first step!

Feasibility Study Droughts

Next Steps

Long-term perspective:

- Add component to monitor meteorological drought
  - Analysis of precipitation data (e.g. ECMWF)
  - Possibly Standardized Precipitation Index (SPI) as first-choice indicator
- Add component to monitor hydrological drought
  - Analysis of measured (low flow) discharge data (EFAS updating)
  - Analysis of forecasted discharges (EFAS! … after finishing calibration)
  - Use already developed methodologies (e.g. Q90, BFI, …)
- Improve vegetation representation in LISFLOOD
  - Include RS information on vegetation, e.g. albedo, FAPAR (MERIS)
- … resulting in an integrated drought simulation tool

  >> European Drought Alert System

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Acknowledgements

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… with contributions of members of the
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ERA40 data:	Giovanni Franchello, Ben Gouweleeuw
GIS, RS:	Katalin Bodis, Giovanni Laguardia
EFAS:	Jutta Thielen

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Contact Details

Joint Research Centre

stefan.niemeyer@jrc.it

European Commission
DG Joint Research Centre
Institute for Environment and Sustainability
TP 261, 21020 Ispra (VA), Italy
Tel +39-0332-78-5820, fax -6653

http://natural-hazards.jrc.it

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Thank you!

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