Tatiana Loboda, Olga Krankina, Igor Savin, Eldar Kurbanov, Joanne Hall

LAND MANAGEMENT CHANGES AND IMPACT OF EXTREME DROUGHTS IN EUROPEAN RUSSIA

EUROPE AND METEOROLOGICAL DISASTERS

- Meteorological disasters include:
  - droughts
  - floods
  - wind storms
  - snow storms
  - extremely low or high temperatures
- Most are related to persistent atmospheric blocking events

ATMOSPHERIC BLOCKING

Characteristics (CPC NOAA):

- 2 separate branches of westerly flow over a considerable longitudinal extent
- Reverse (Easterly) flow south of the blocking ridge
- Meridional flow (deep troughs) both sides of blocking ridge

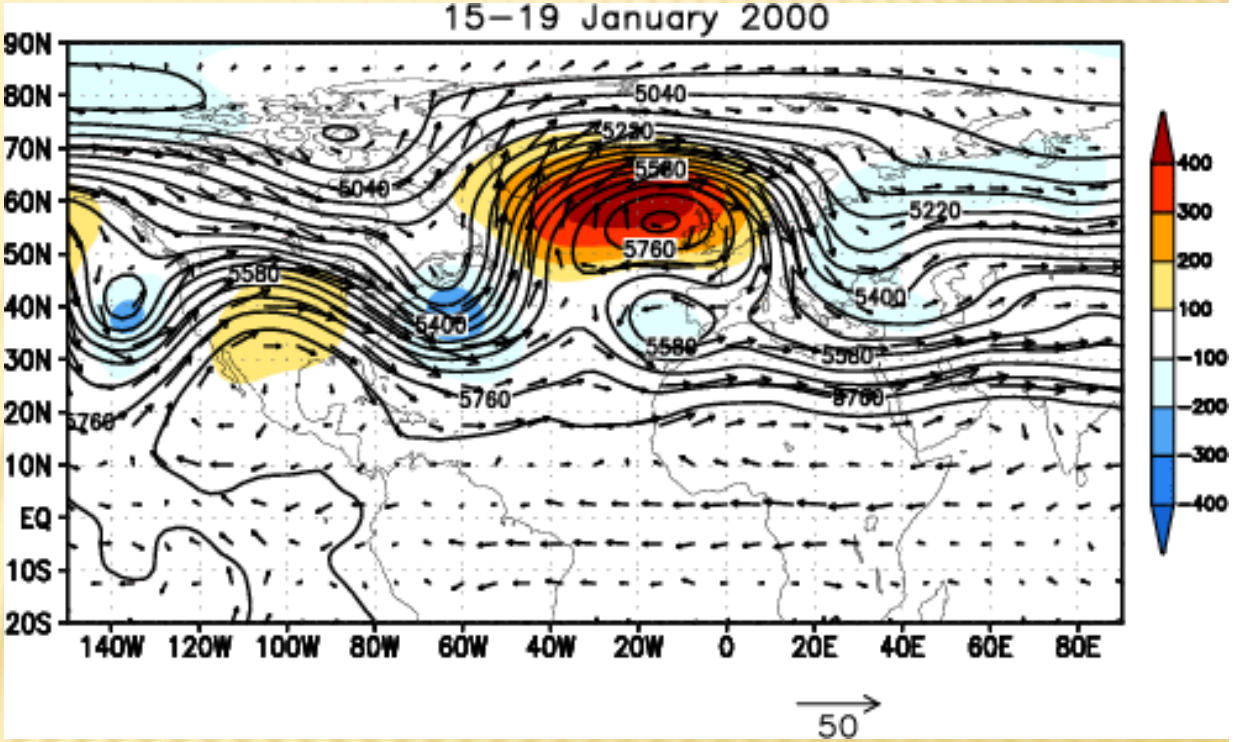


Image from http://www.cpc.ncep.noaa.gov/products/precip/CWlink/blocking/background/atlantic_case.shtml

BLOCKING INDEX

- Tibaldi and Molteni (1990) Blocking Index
  - Calculates the GPH gradient at each specified longitude

- GHGS Index
  - Max value = amplitude of block
  - Longitude of max value = measure of phase

$$GHGS = \left[\frac{Z(\varnothing_o) - Z(\varnothing_s)}{\varnothing_o - \varnothing_s} \right]$$

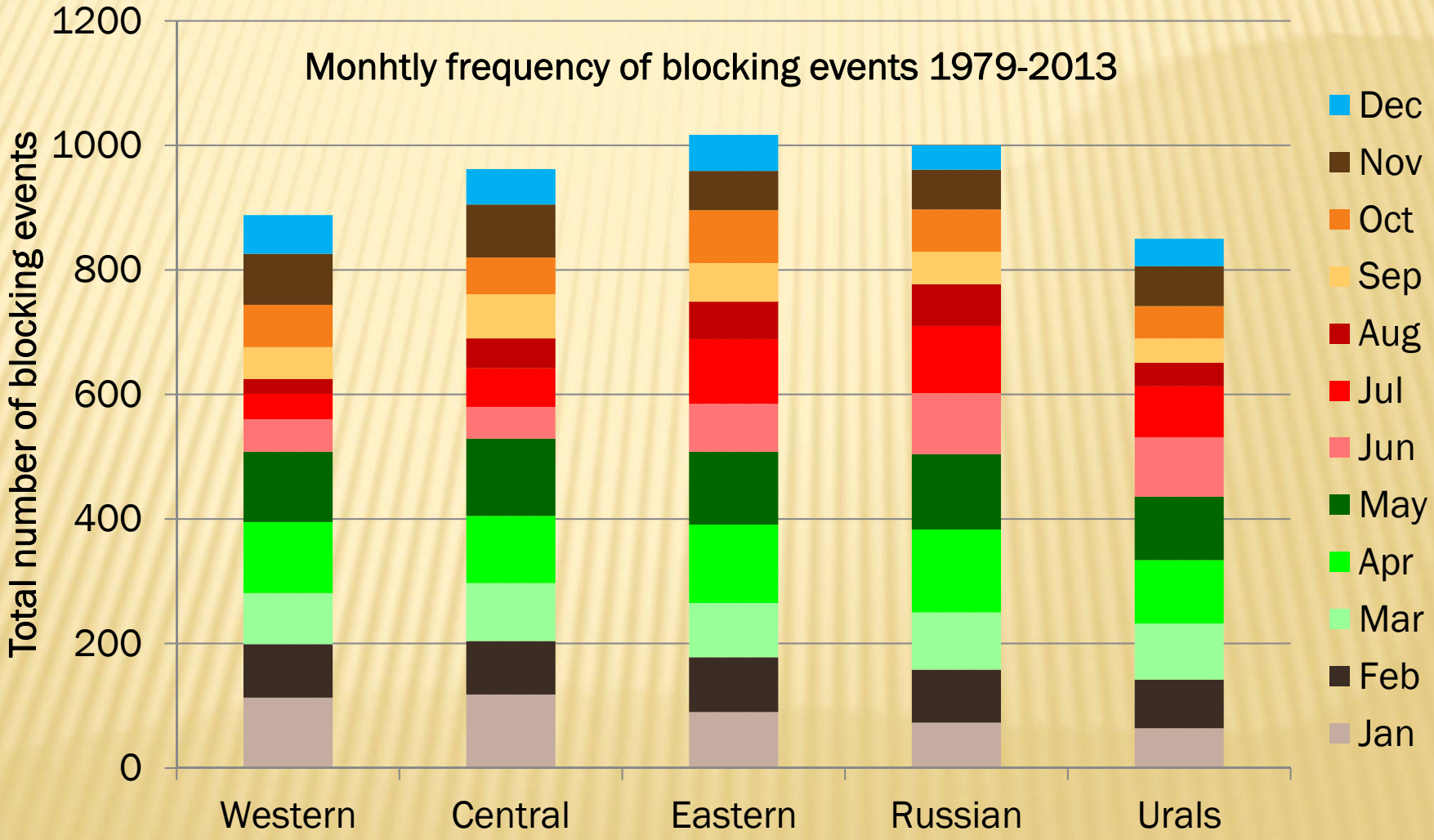
- Blocking Criteria:
  - GHGS > 0
  - GHGN < -10deg/lat

$$GHGN = \left[\frac{Z(\varnothing_n) - Z(\varnothing_o)}{\varnothing_n - \varnothing_s} \right]$$

- NCEP-DOE Reanalysis 2:
  Daily 500hPa geopotential height at 12:00pm 1979-2013

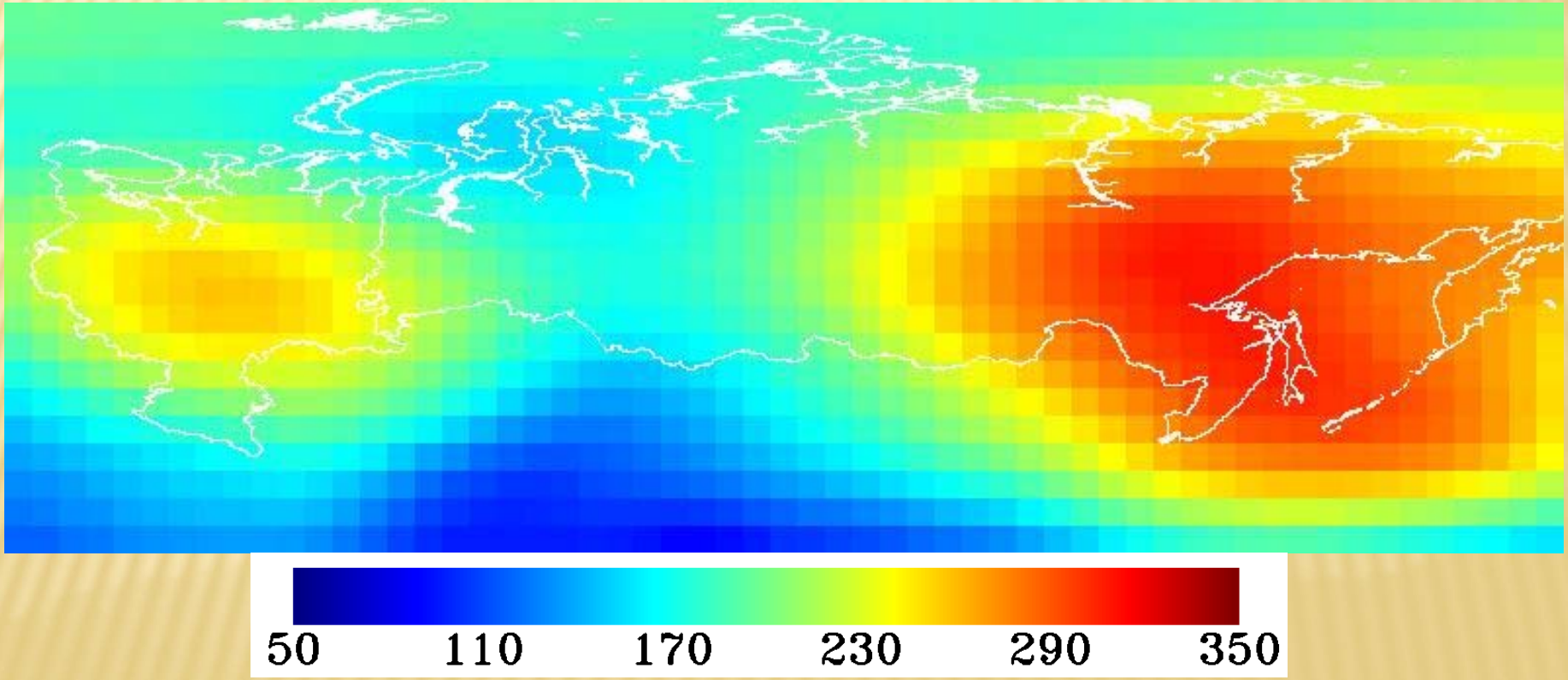
$\varnothing_n = 80°N + \delta$
$\varnothing_o = 60°N + \delta$
$\varnothing_s = 40°N + \delta$
$\delta = -5°, -2.5°, 0°, +2.5°, +5°$
Z = Geopotential Height

BLOCKING EVENTS ARE COMMON IN EUROPE



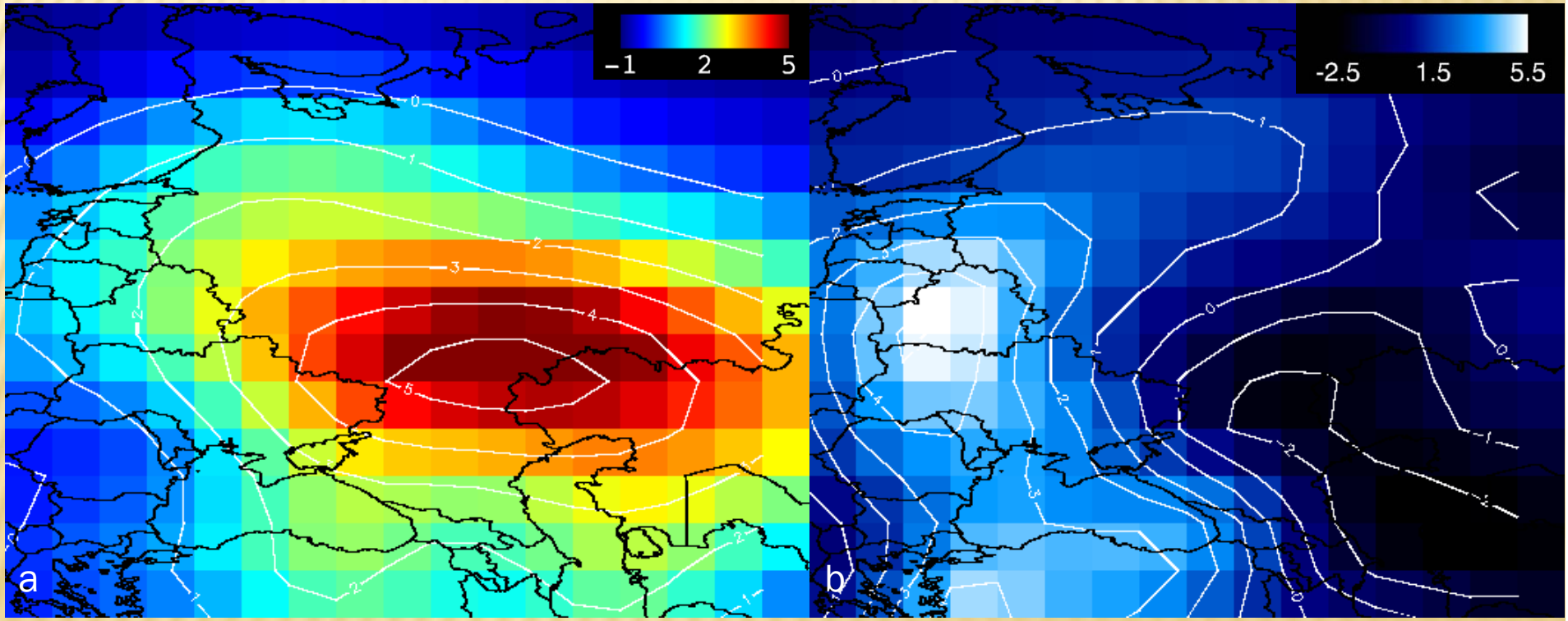
SUMMER 2010 BLOCKING EVENT

JJA 2010 : 500hPa Geopotential Height Anomaly
Climatology Base Period
(1979 – 2012)



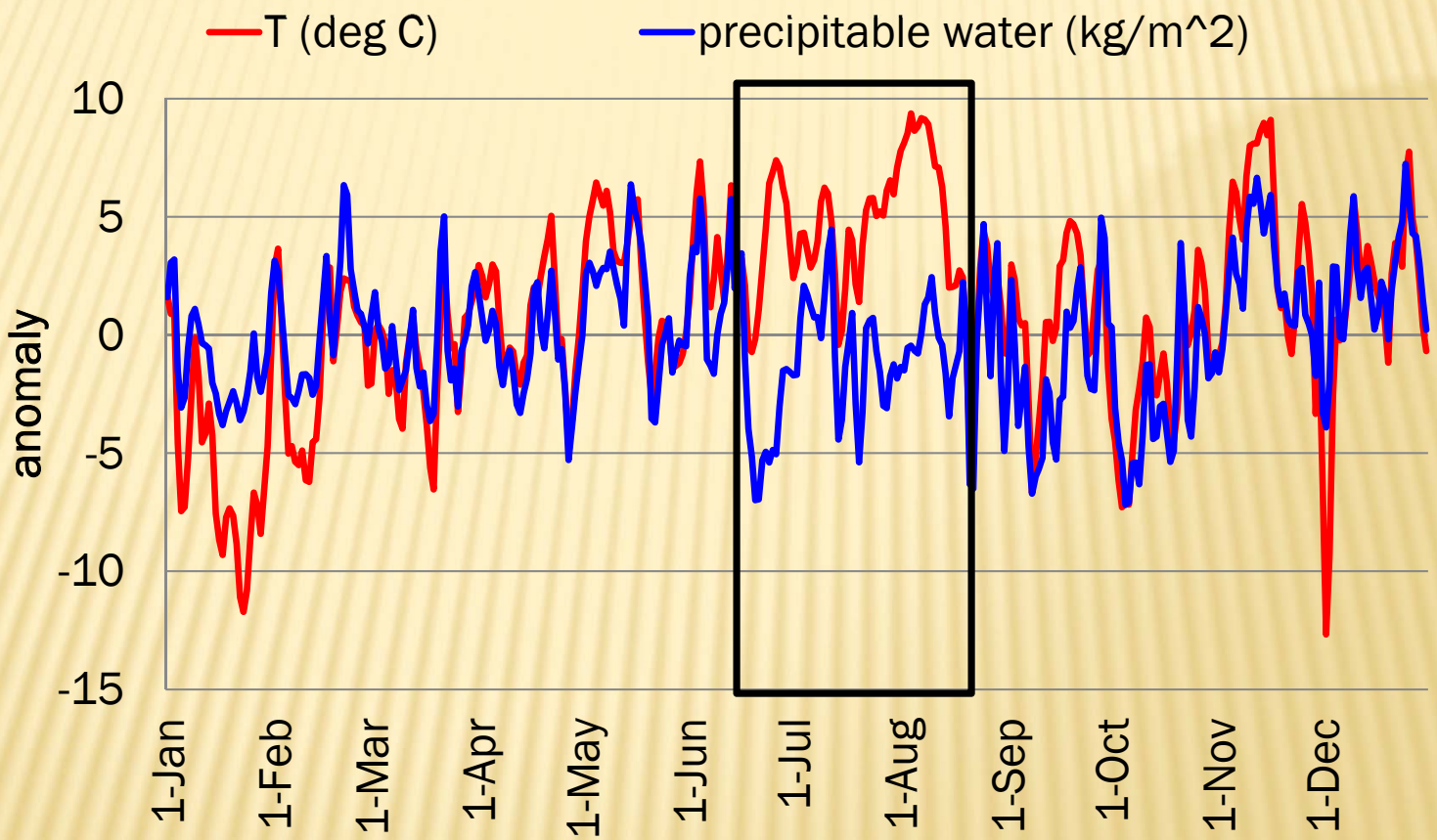
SUMMER 2010 DROUGHT

2010 summer mean daily anomaly from the 2001-2012 base in European Russia (data source: NCEP Reanalysis II data).



a) temperature (degrees C) b) precipitable water (kg m^{-2})

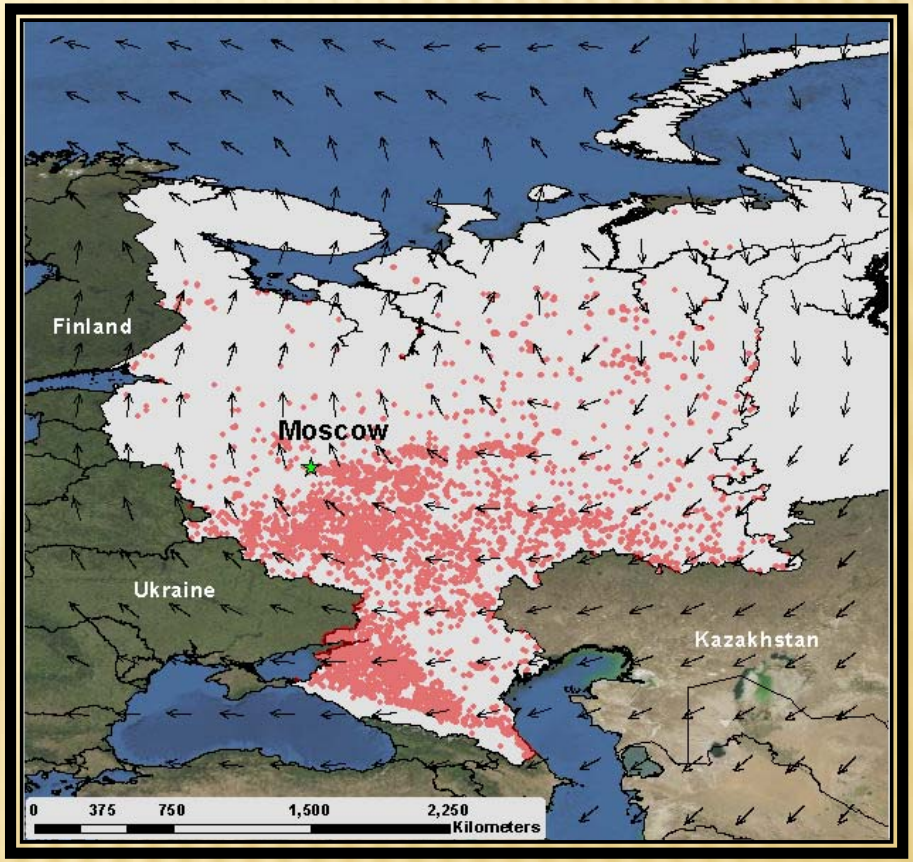
SUMMER 2010 DROUGHT

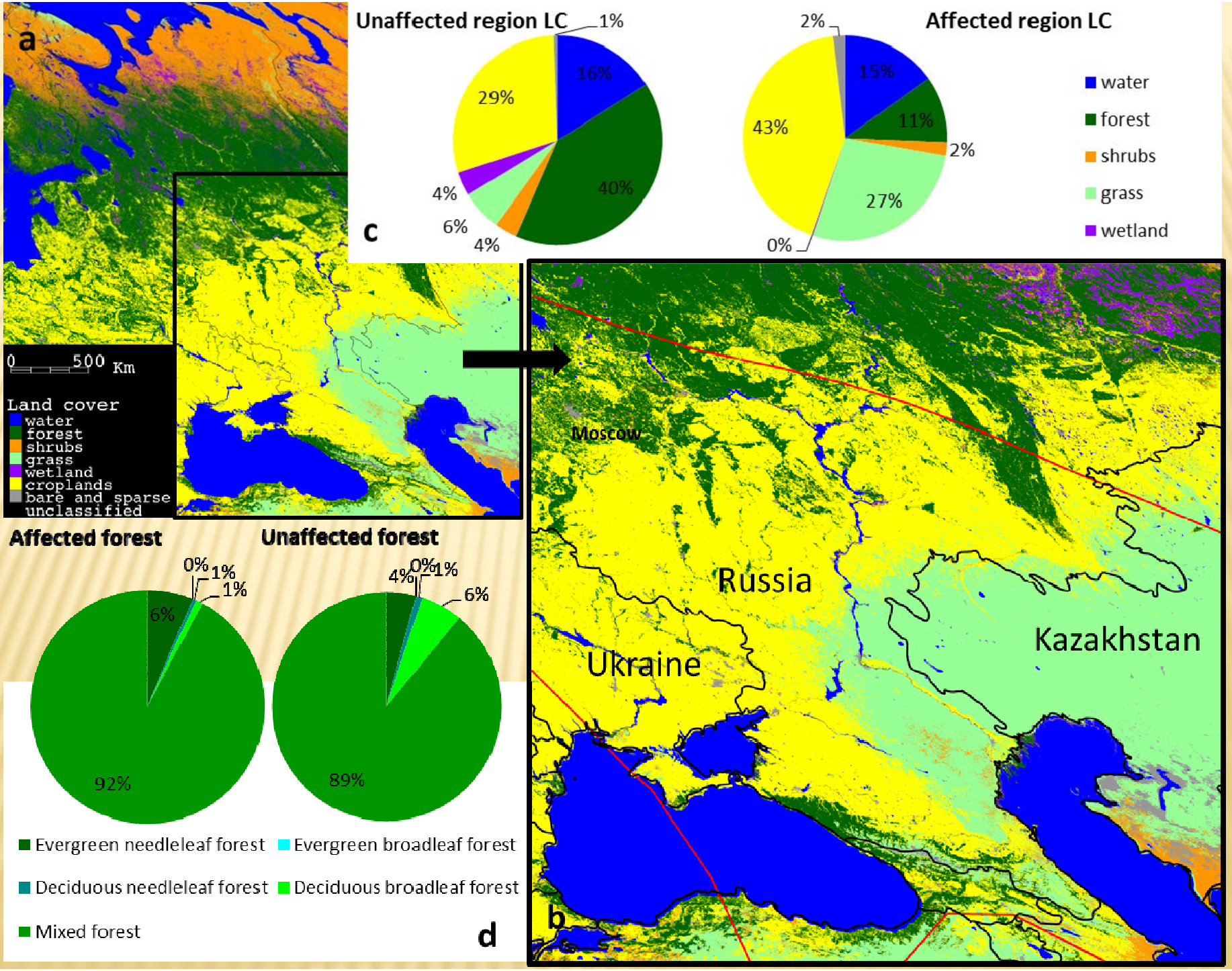


Daily temperature and precipitation anomaly during 2010 from NCEP Reanalysis data

MAJOR IMPACTS OF SUMMER 2010 DROUGHT

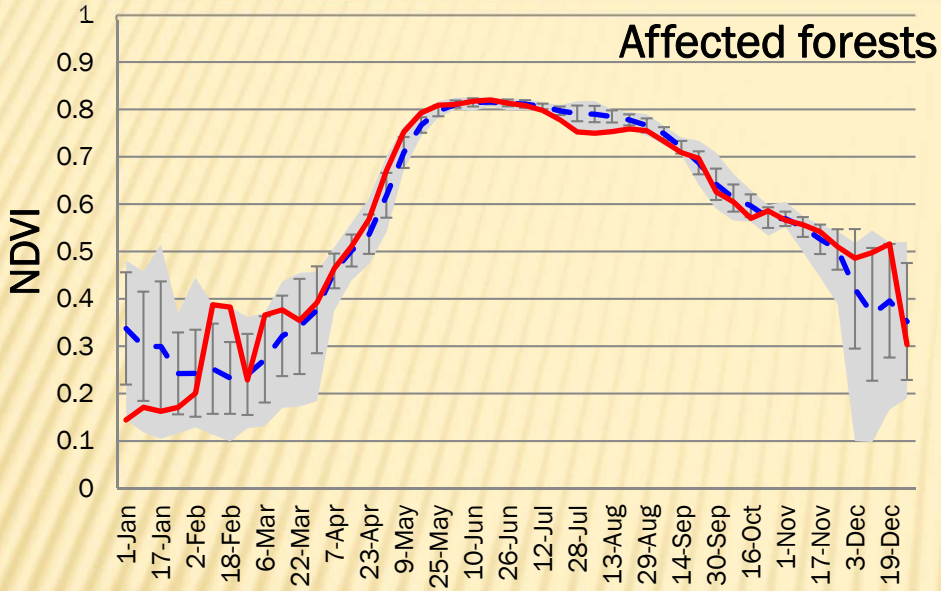
- Crop failure
  - grain production in Russia dropped by 20--30% compared to 2009
- Forest and peat fires
  - Biggest fire year on record since 2001 (likely since 1972)
- Human health impacts
  - Estimates > 55,000 deaths
  - Direct heat impact
  - Extreme concentrations of emissions

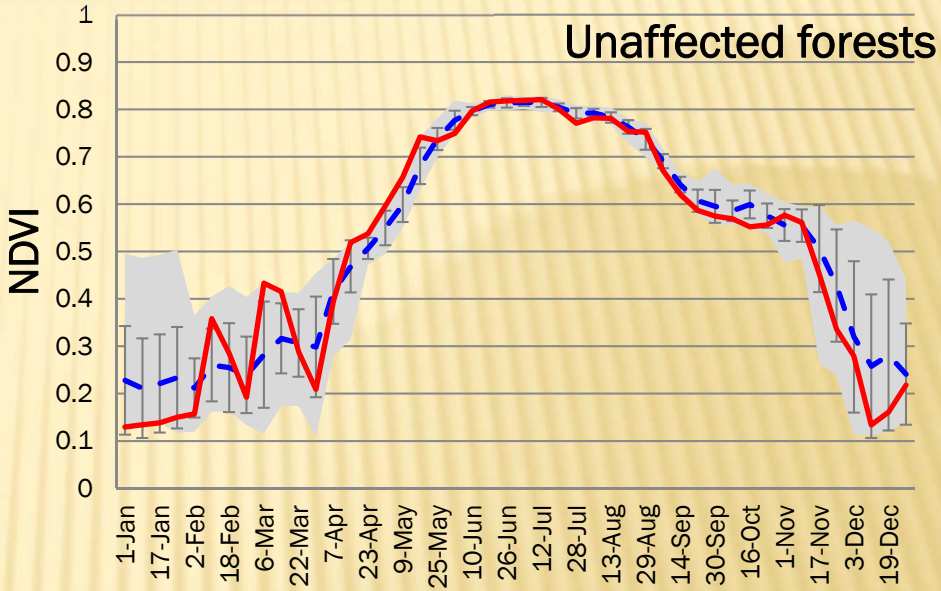


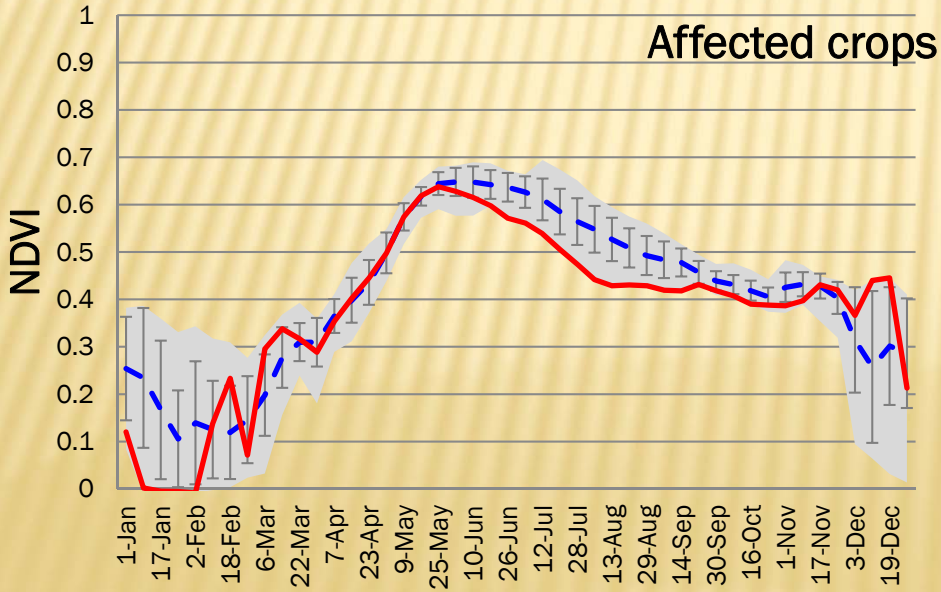

a
0 500 Km
Land cover
water
forest
shrubs
grass
wetland
croplands
bare and sparse
unclassified
Unaffected region LC
1%
16%
29%
40%
4%
6%
4%
c
2%
Affected region LC
15%
43%
11%
2%
27%
0%
water
forest
shrubs
grass
wetland
Moscow
Russia
Kazakhstan
Ukraine
b
Affected forest
Unaffected forest
0%
1%
1%
6%
92%
4%
0%
1%
6%
89%
Evergreen needleleaf forest
Evergreen broadleaf forest
Deciduous needleleaf forest
Deciduous broadleaf forest
Mixed forest
d

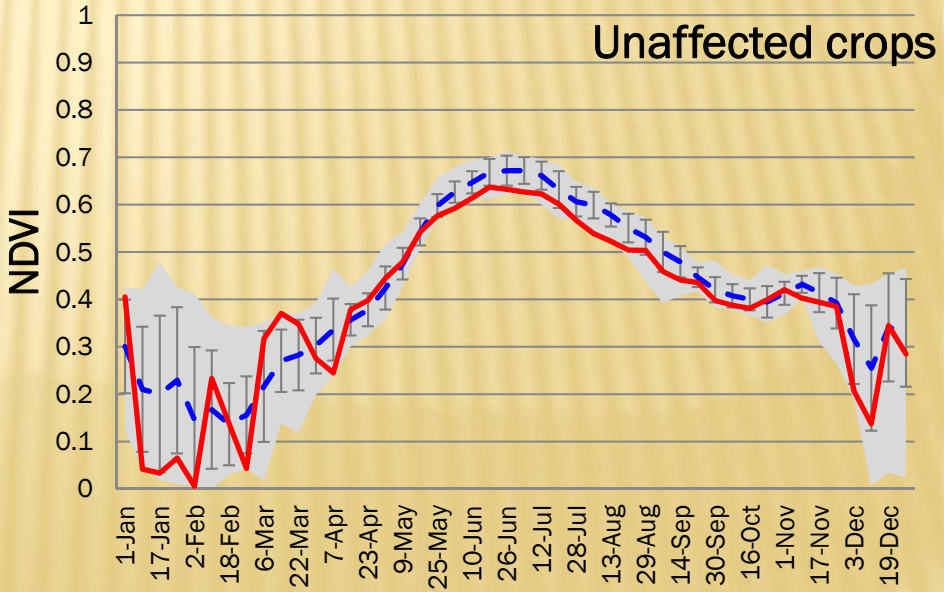
NDVI TRENDS IN SUMMER 2010

2010 NDVI 2003-2012 mean NDVI 2003-2012 range NDVI 2003-2012 ±1 σ



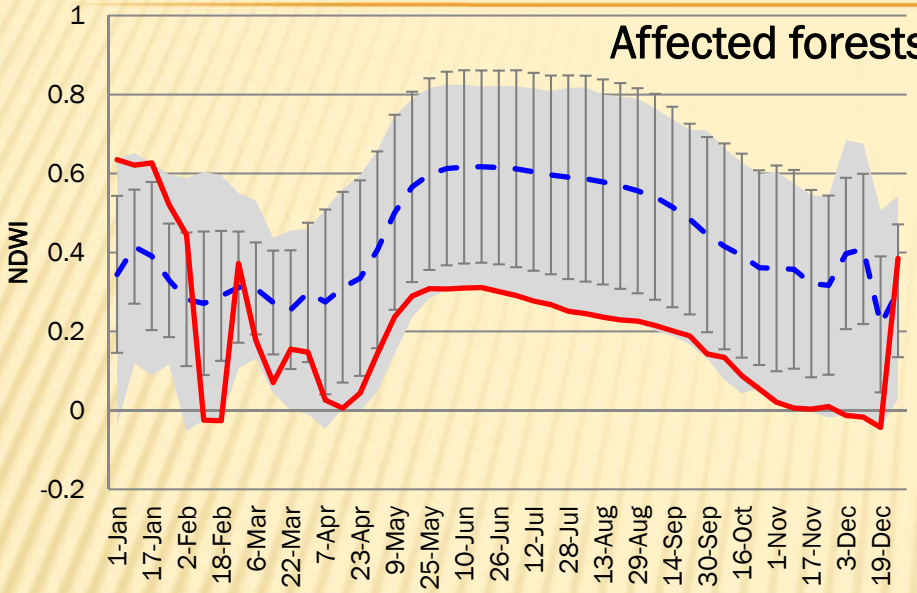


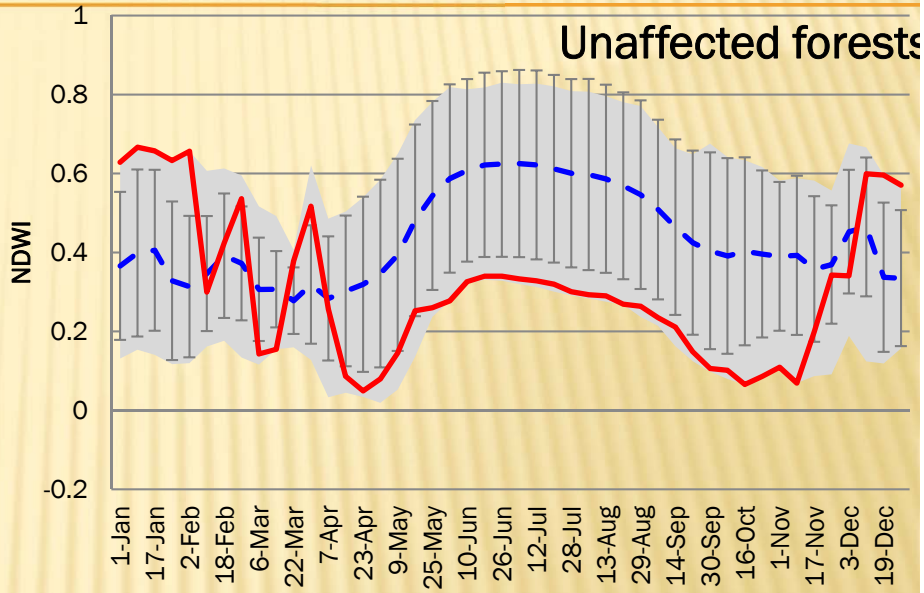


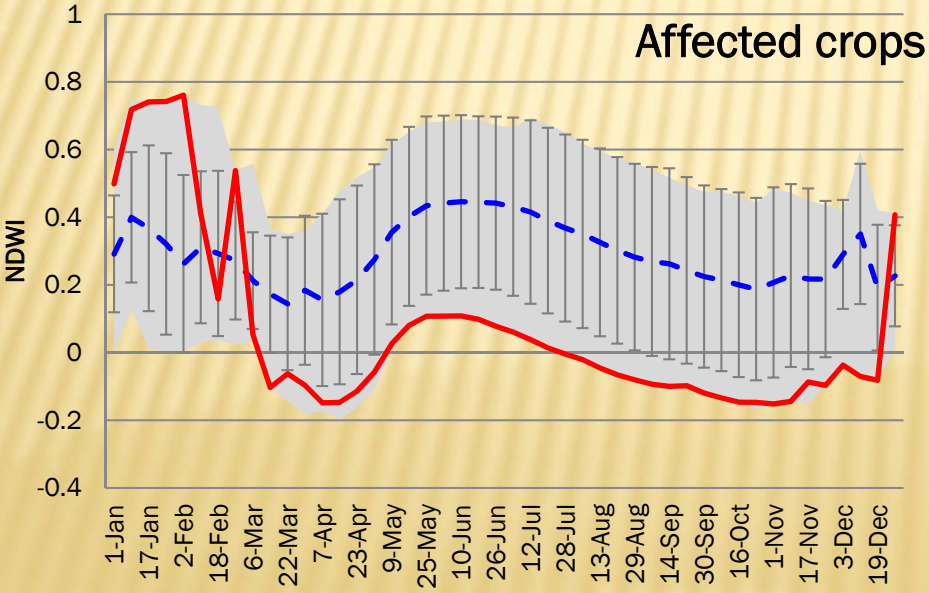


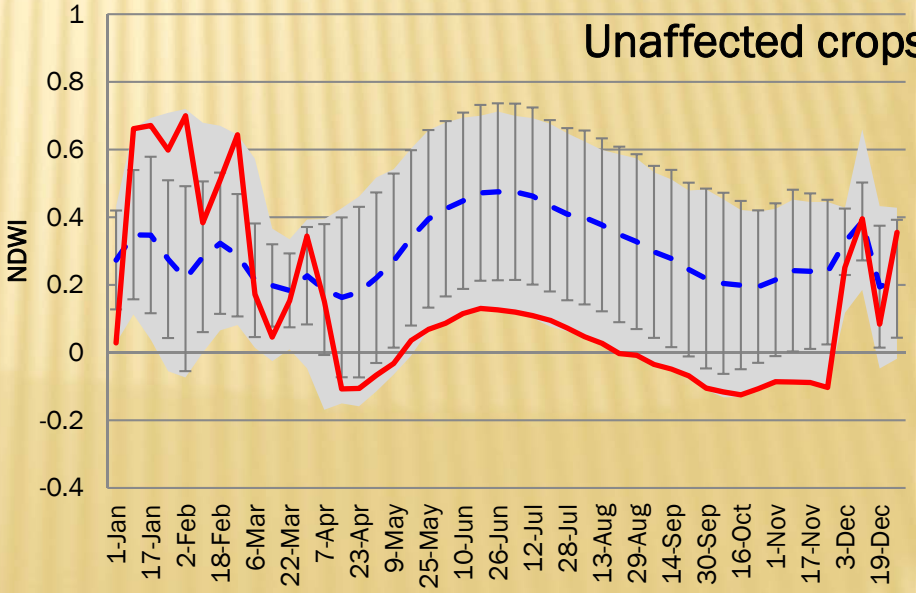
NDWI TRENDS IN SUMMER 2010

2010 NDWI 2003-2012 mean NDWI 2003-2012 range NDWI 2003-2012 ±1 σ

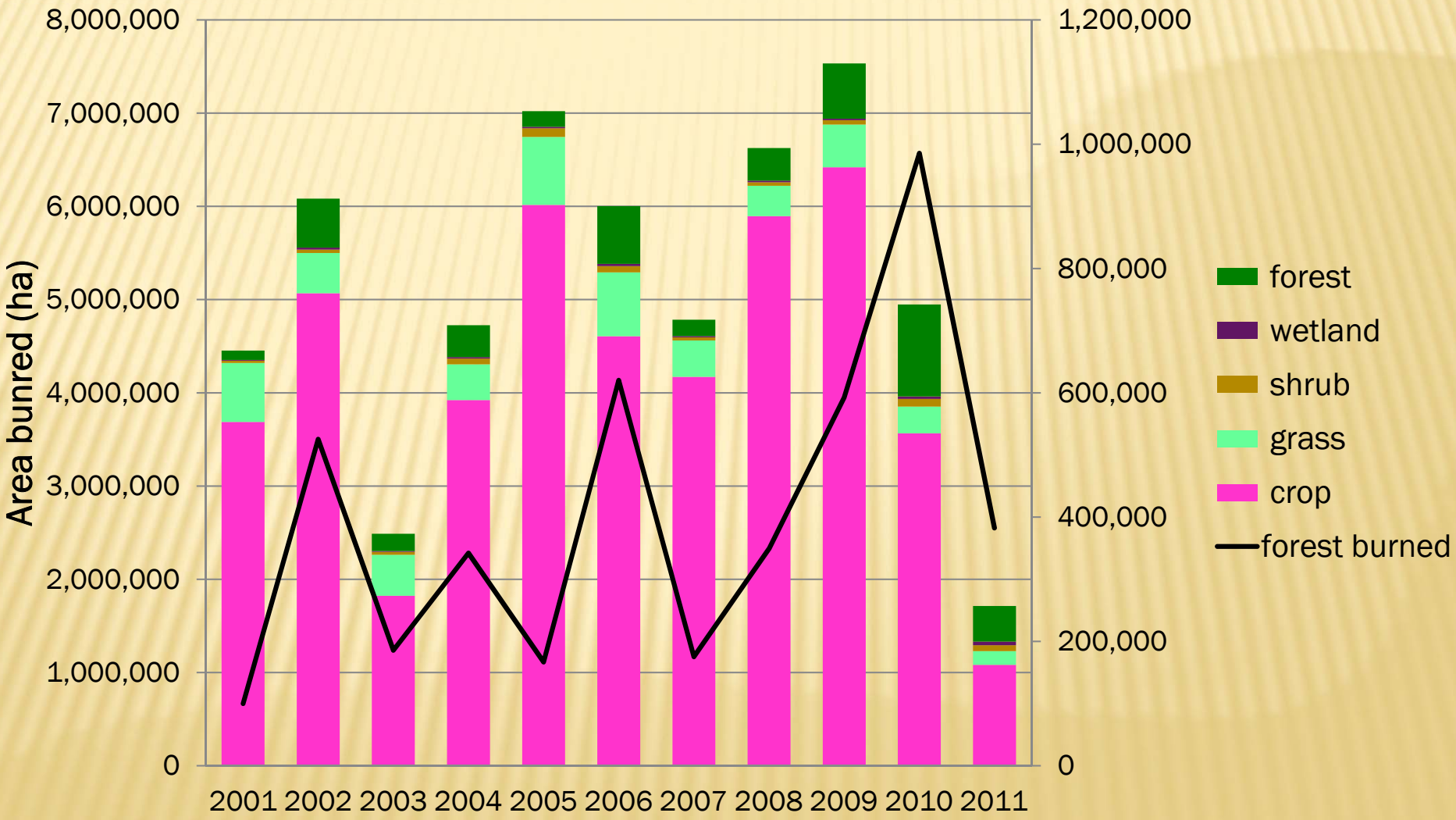


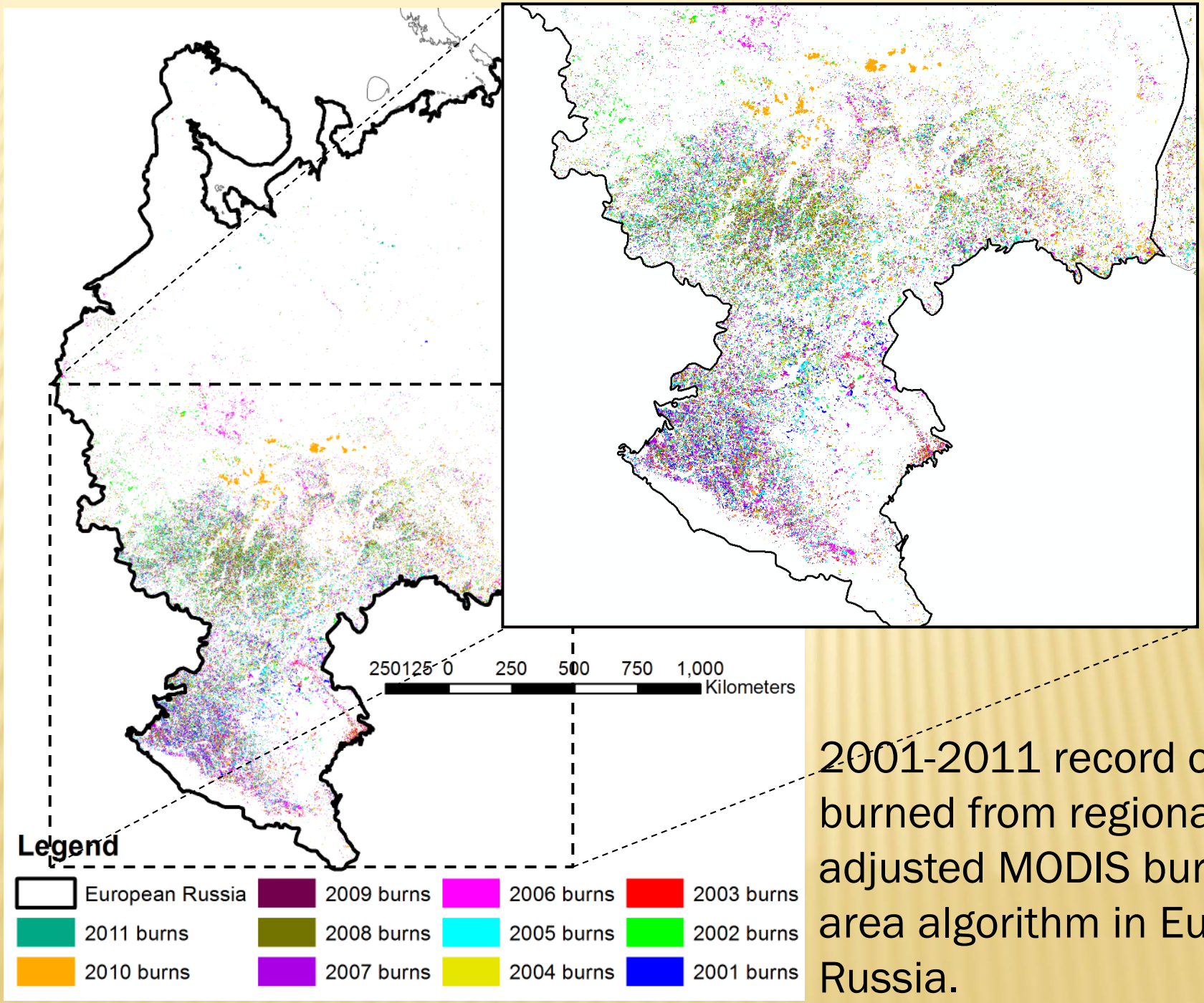






SUMMER 2010 IMPACT OF BURNING

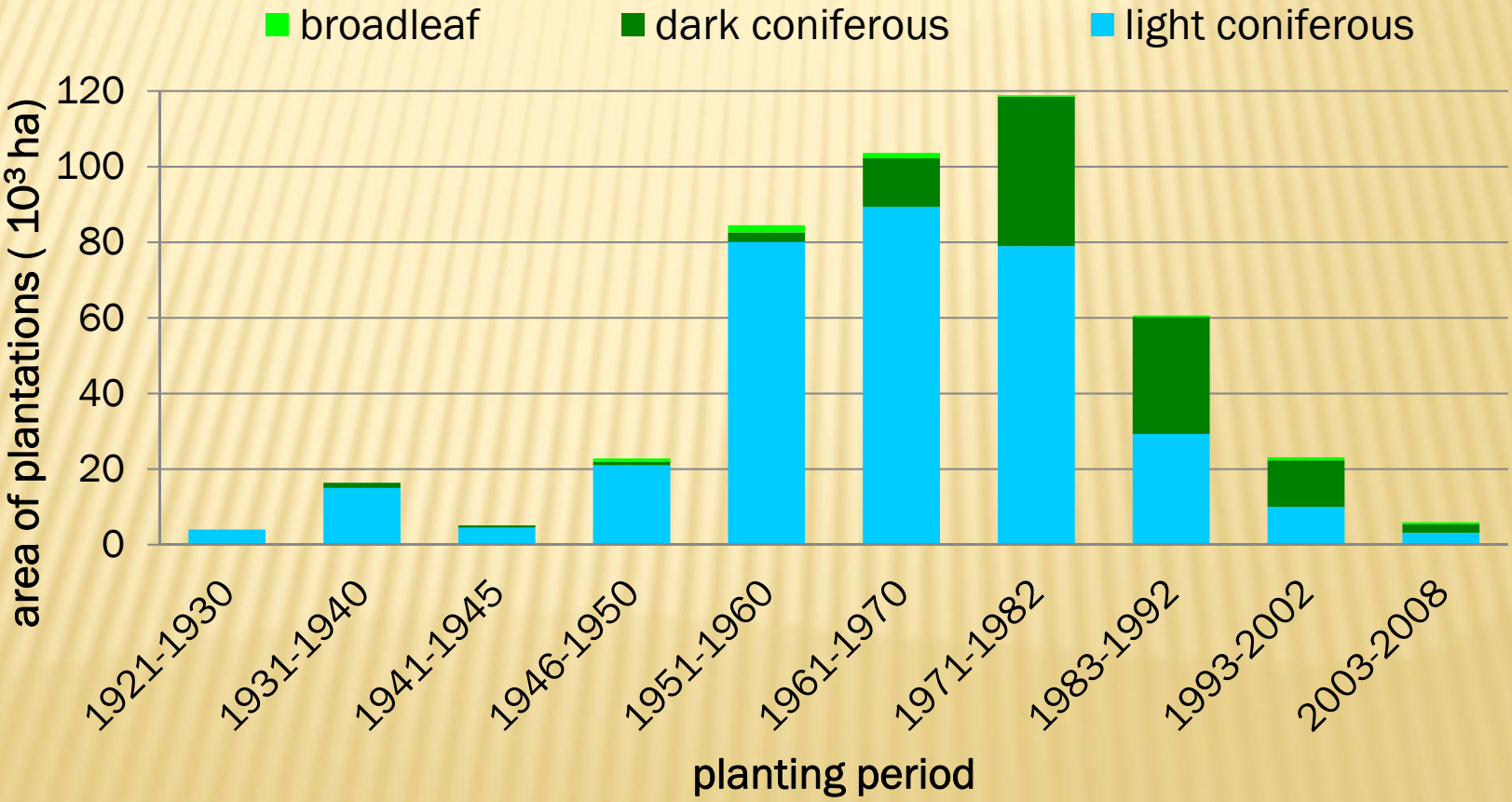




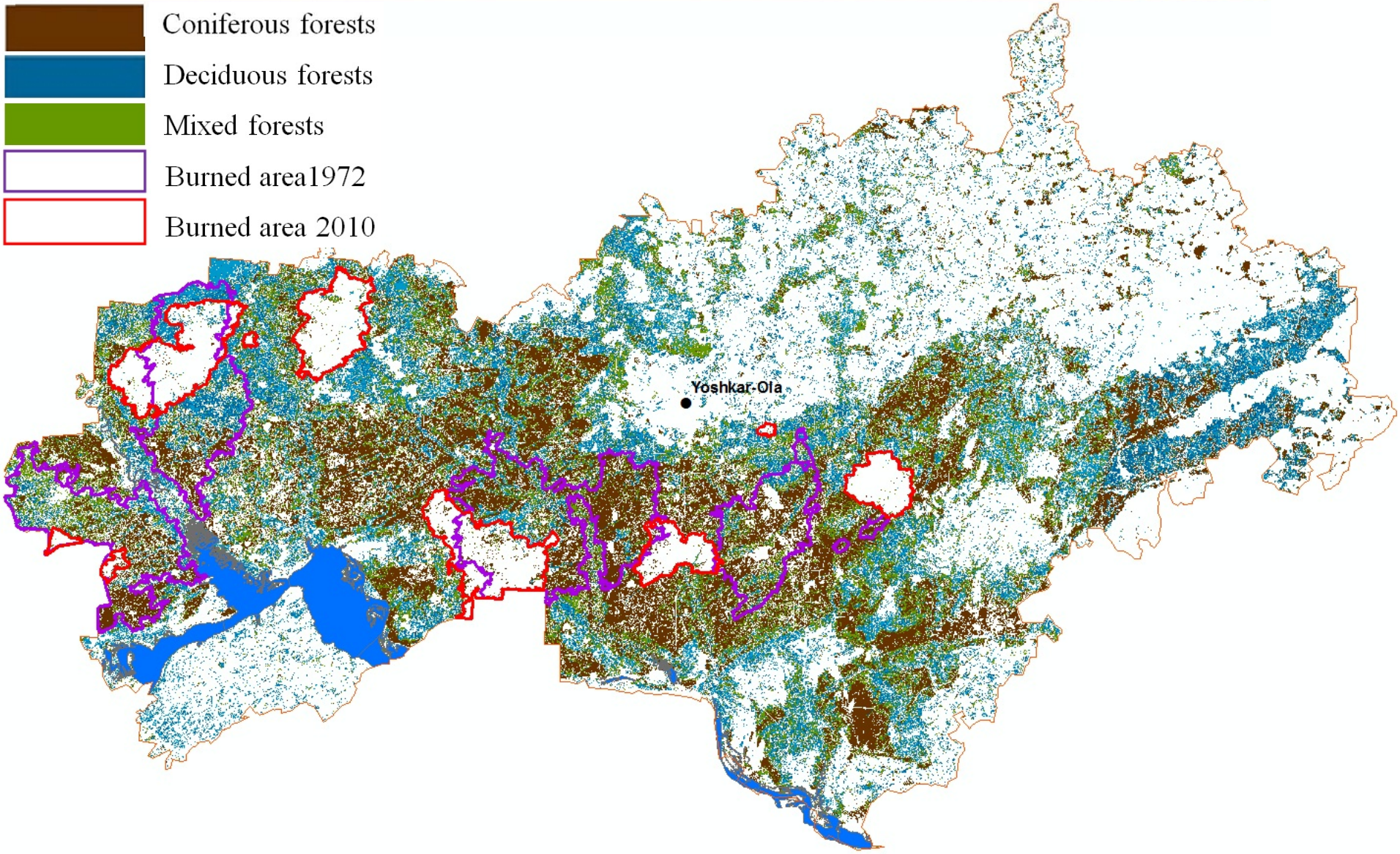
2001-2011 record of area burned from regionally-adjusted MODIS burned area algorithm in European Russia.

FORESTRY POLICY AND DROUGHT

Dynamics of forest types in plantations of forest fund of Republic Mari El, Russia



COMPLETE TREE MORTALITY IN 2010 FIRES



AGRICULTURAL PRACTICES AND DROUGHT

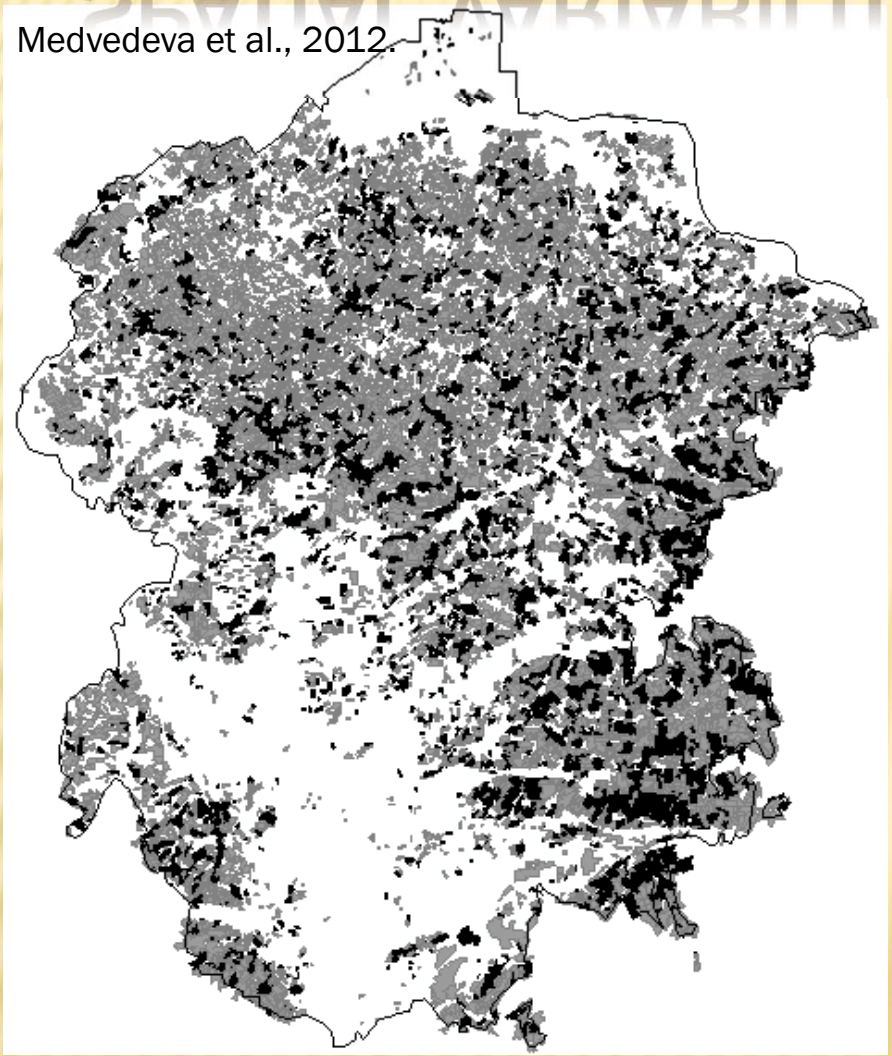
- Water consumption needs differ by crop types:
  - spring cereal crops ~450-650 mm (for the vegetative season)
  - corn ~ 500-800 mm
  - potatoes ~ 500-700 mm
  - sugar beet ~ 550-750 mm
  - sunflower ~ 600-1000 mm
- In the market economy crop rotation is driven by crop price
- Increase in sunflower and corn (almost 2X across Russia) → increase in moisture demands

SATELLITE MAPPING OF CROP GROUPS

- Multi-temporal MODIS observations allow to map broad crop groups based on:
  - the specific shape of the NDVI curve at the beginning of the season,
  - the date of the beginning of the vegetative season
  - the date of seasonal NDVI maximum
- Groups mapped:
  - winter(winter wheat, winter barley, winter rye),
  - early spring (spring barley, spring wheat)
  - late spring (potatoes, maize, sunflower, millet, sugar beets)

SPATIAL VARIABILITY IN CROP DAMAGE

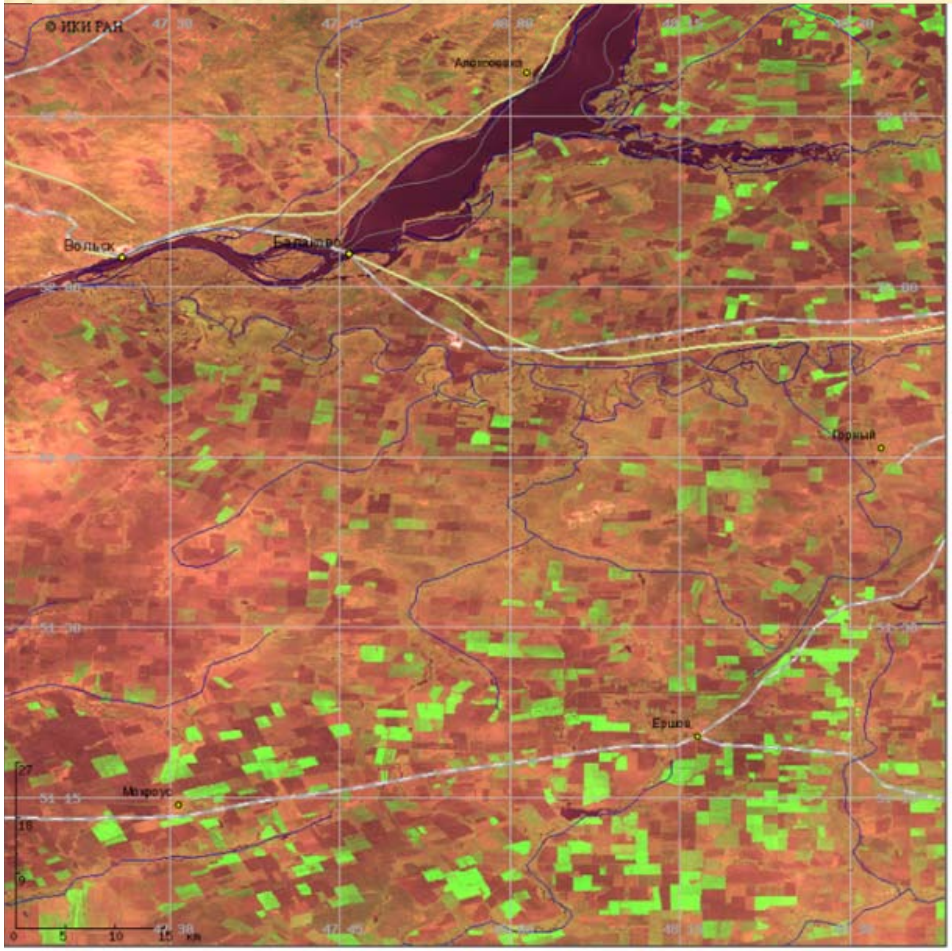
Medvedeva et al., 2012.

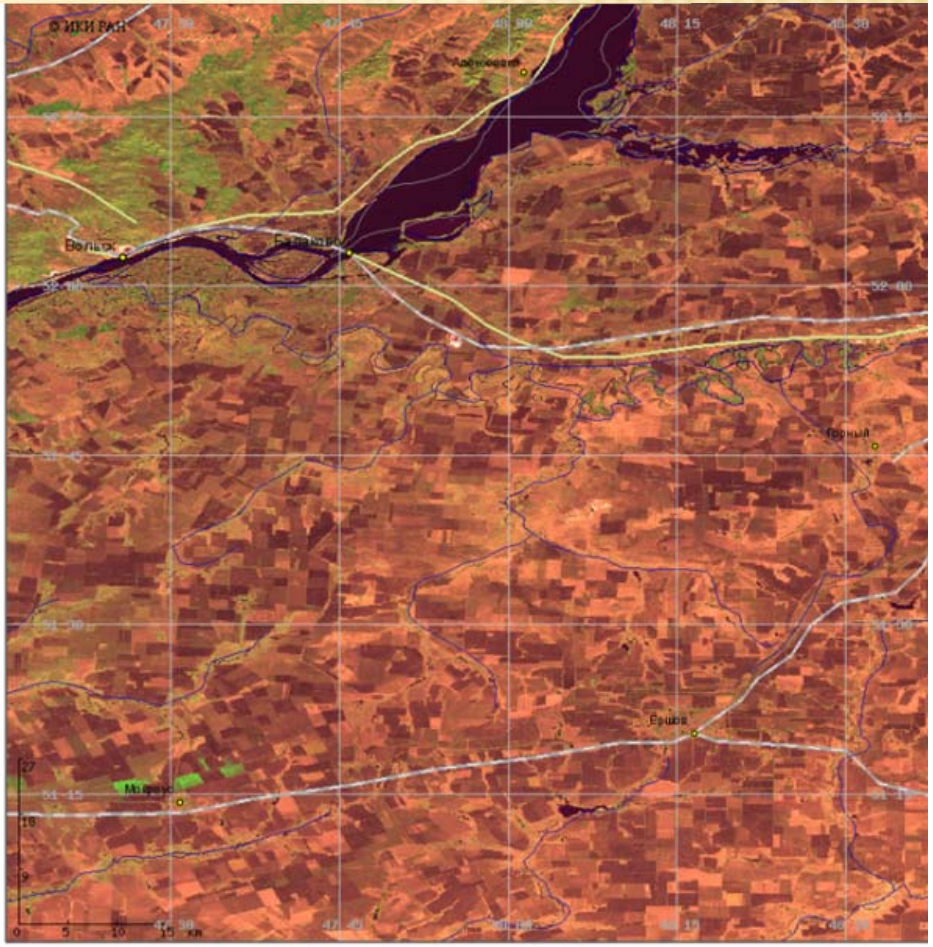


Chuvashia crops damaged (black) and undamaged (gray) by 2010 drought

- Impact of crop rotation:
  - Late season crops 5 years out of 10 - 2% of fields damaged
  - 6 years out of 10 - 9%
  - 7 years out of 10 - 24%
  - 8 years out of 10 – 40%

POST-DROUGHT WINTER CROP PLANTING FAILURE

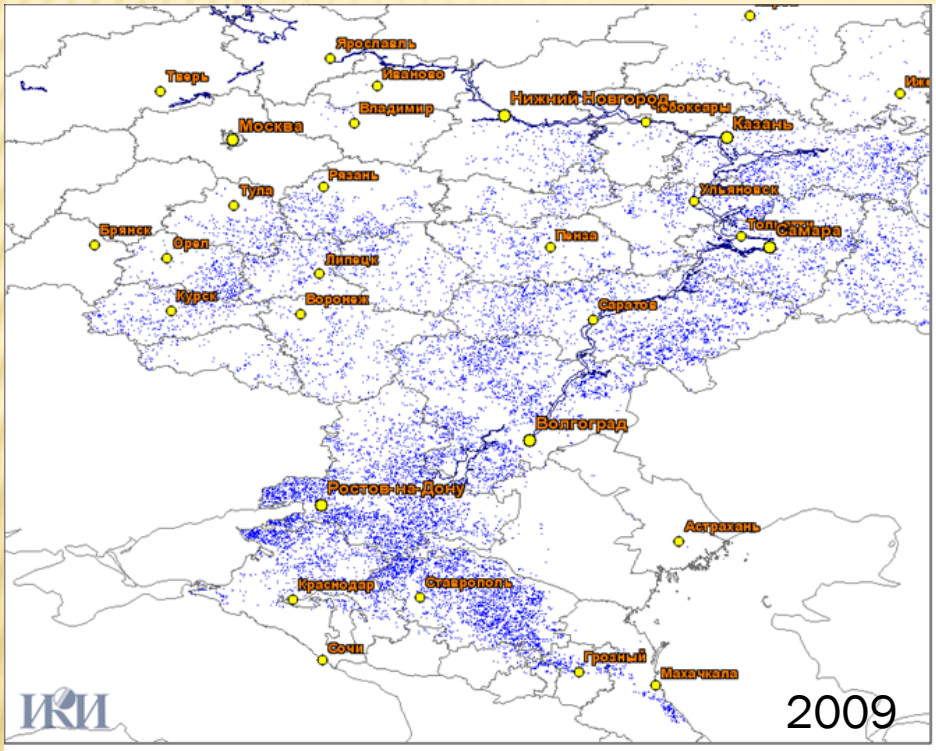


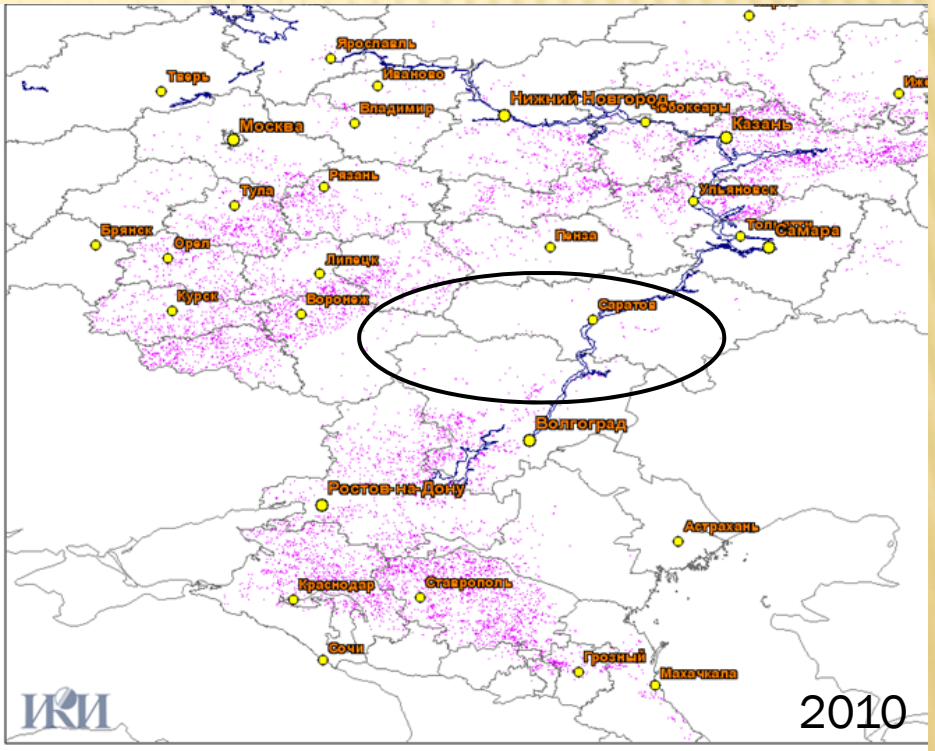


2009 2010

Landsat-based assessment

POST-DROUGHT WINTER CROP PLANTING FAILURE (CONT)



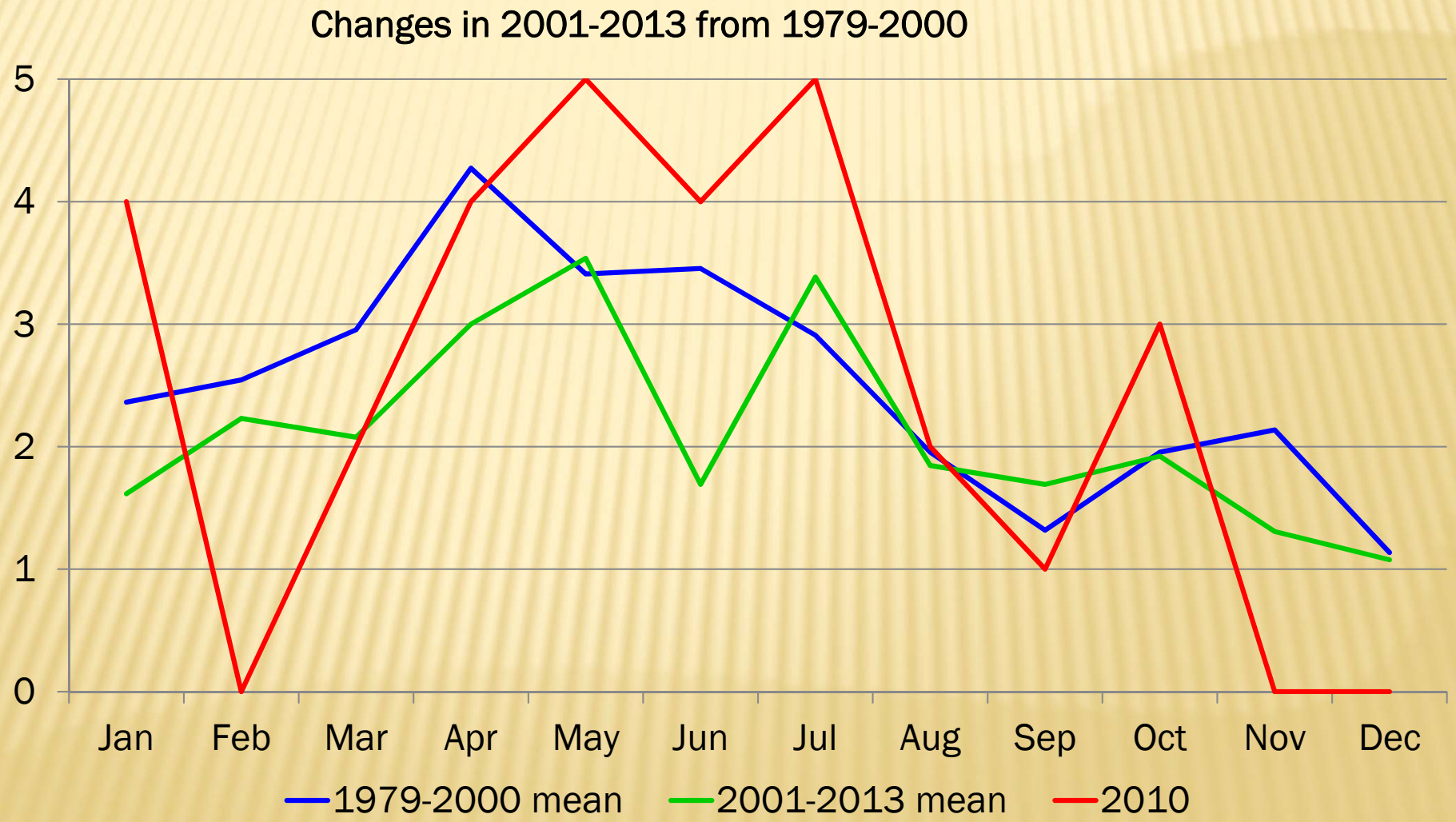


Russian VEGA satellite-services data

CONCLUSIONS

- Europe in general and Russia and Eastern Europe in particular are impacted by blocking events and associated disasters
- In the past 13 years there have been fewer blocking events during June – August

RECENT CHANGES IN FREQUENCY OF BLOCKING EVENTS: EXAMPLE FROM EUROPEAN RUSSIA



CONCLUSIONS

- Europe in general and Russia and Eastern Europe in particular are impacted by blocking events and associated disasters
- In the past 13 years there have been overall fewer blocking events during June – August
- Future projections indicate a likely increase in the frequency of blocking events
- Land management strategies should become an integral part of disaster preparedness planning