



Final International ASTRA Conference  
December 10-11, 2007, GTK, Espoo

# Nutrient Load and Climate Change in the Kokemäenjoki Catchment Area

*Tom Frisk, Ämer Bilaletdin and  
Heikki Kaipainen*

*Pirkanmaa Regional Environment Centre,  
Tampere, Finland*

- 1. Introduction**
- 2. Case study area**
- 3. The modelling system**
- 4. Expected impacts of climate change**
- 5. Future tasks**

# 1. INTRODUCTION

- **Pirkanmaa Regional Environment Centre (PREC) is a regional governmental organisation working for the Ministry of Environment, Finland (partly for the Ministry of Agriculture and Forestry).**
- **Within the ASTRA project, the task of PREC in its case study was to assess the impacts of climate change on nutrient (phosphorus and nitrogen) flows in the Kokemäenjoki drainage basin.**
- **The assessment was based on the previous studies that PREC has conducted as well as a very tight cooperation with the Finnish Environment Institute (SYKE)**

# 1. INTRODUCTION

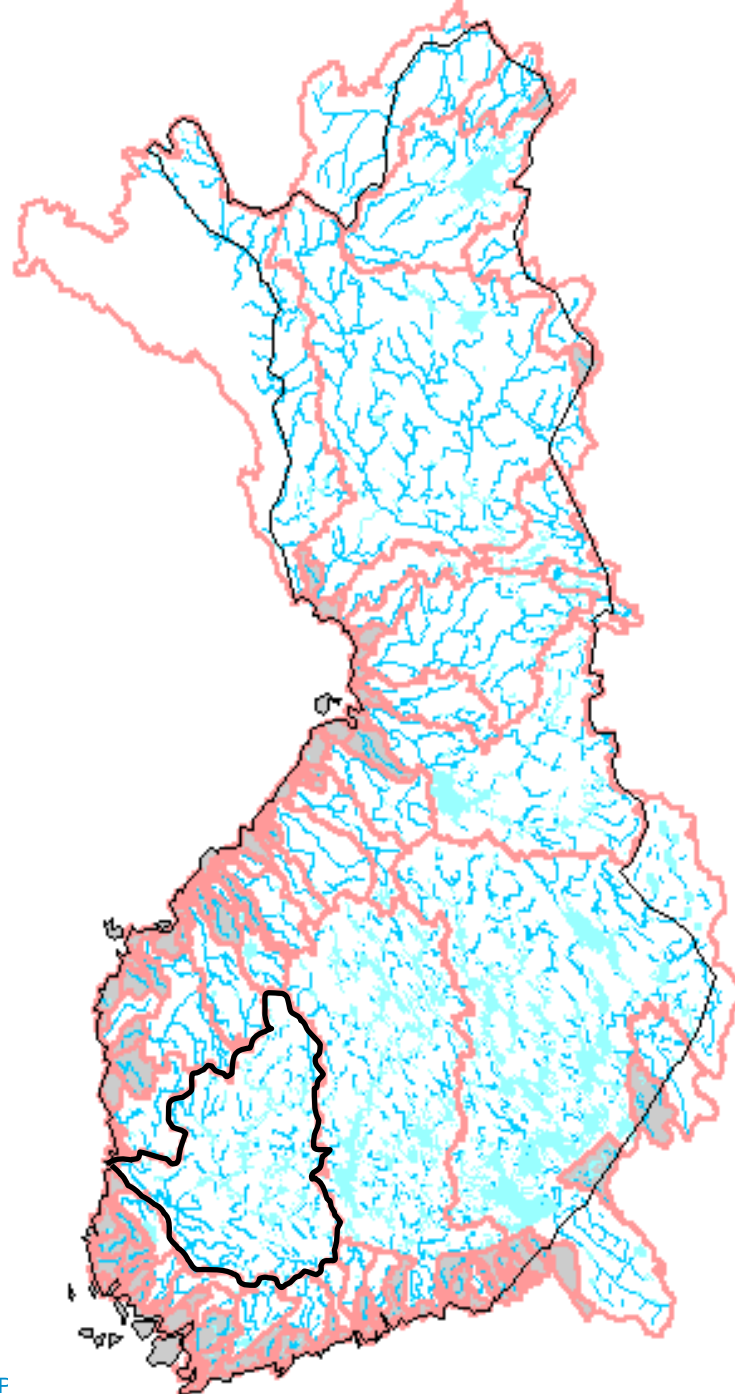
- **Pirkanmaa Regional Environment Centre (PREC) is a regional governmental organisation working for the Ministry of Environment, Finland (partly for the Ministry of Agriculture and Forestry).**
- **Within the ASTRA project, the task of PREC in its case study was to assess the impacts of climate change on nutrient (phosphorus and nitrogen) flows in the Kokemäenjoki drainage basin.**
- **The assessment was based on the previous studies that PREC has conducted as well as a very tight cooperation with the Finnish Environment Institute (SYKE)**

- 
- 
- **INTRODUCTION (cont.)**

- **Impacts of climate change on nutrient flows and eutrophication were quantitatively assessed for the first time in the Finnish Research Programme on Climate Change (SILMU) in 1990-1996 (PREC & SYKE).**
- **PREC has long experience about environmental modelling.**
- **In the NUTRIBA project, within the BIREME programme of the Academy of Finland, mechanisms and magnitude of nutrient flows from the catchment of the river Kokeäenjoki were studied (PREC, SYKE and other partners).**

## 2. CASE STUDY AREA

- **The study area, Kokemäenjoki river basin, is the fourth largest catchment in Finland with a total surface area of 27 000 km<sup>2</sup> and an average water discharge of 230 m<sup>3</sup> s<sup>-1</sup>.**
- **The land use in the area varies from intense agriculture to almost totally forested areas, and the population density from sparse (<10 inhabitants per km<sup>2</sup>) in remote rural areas to city densities, with Tampere being the largest one with its ca. 200 000 inhabitants.**
- **The industry is variable, big pulp and paper mills being historically the most critical for the development of present trophic status in surface waters in many areas of the river system.**



## The catchment of the river Kokemäenjoki

---

## ● CASE STUDY AREA (cont.)

- **Nutrient loading from point sources to rivers and lakes and further to the Baltic Sea has decreased since the early 1970s due to the improved wastewater purification of municipalities and industry.**
- **Today, the main challenge in Finland for controlling eutrophication is diffuse nutrient loading which originates from agriculture, forestry and scattered settlements.**
- **The Kokemäenjoki river basin, is characterized by a high proportion of lakes (11 % of total area). Most of the lakes are small (< 5 km<sup>2</sup>) and humic; the colour of water typically varies between 30 and 90 mg Pt l<sup>-1</sup>.**

- 
- 
- **CASE STUDY AREA (cont.)**

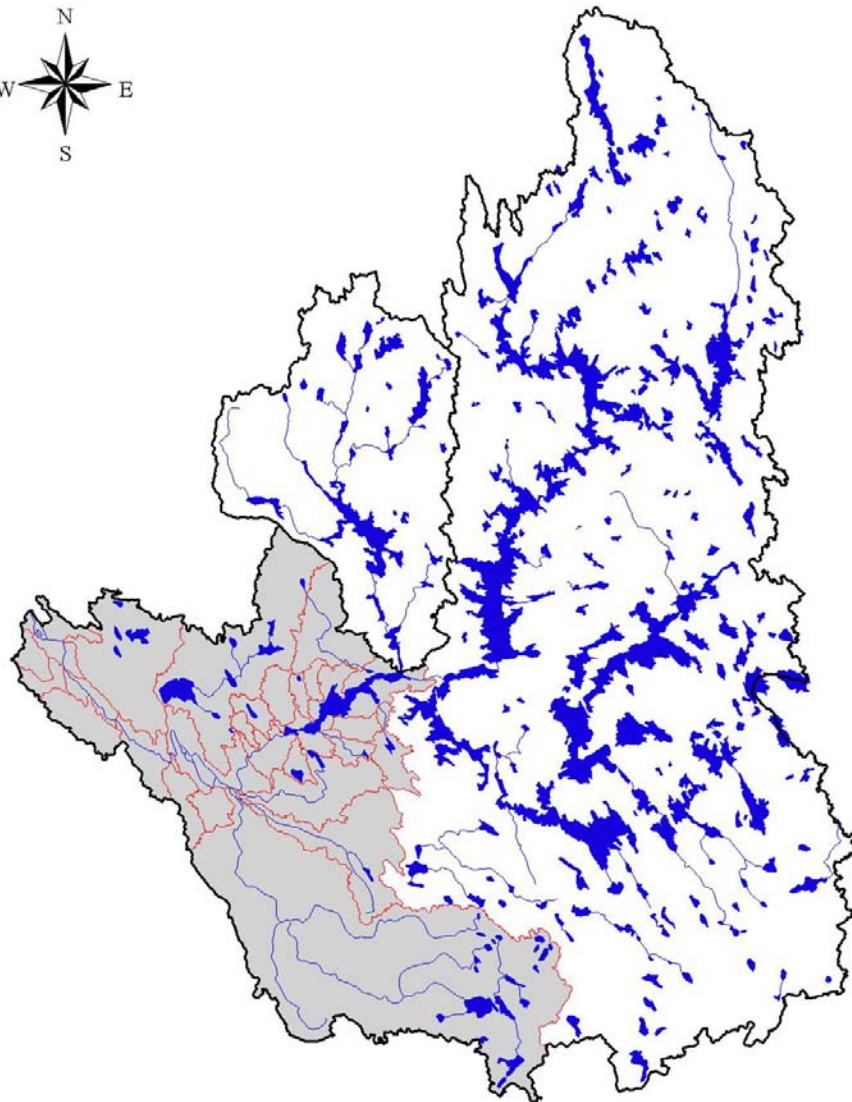
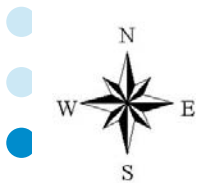
- **In the northern parts of the catchment, point source loading and intense agriculture are of minor importance, and the nutrient concentrations are fairly low.**
- **In contrast, in the southern watercourses where the receiving waters have been loaded by industrial and/or municipal waste waters for decades, or diffuse loading from agriculture is severe, the P and N concentrations**
- **During the last six years (2000-2005) total nutrient loading via the River Kokemäenjoki to the Bothnian Sea has varied between 0.4 and 1.5 t P d<sup>-1</sup> and between 13 and 38 t N d<sup>-1</sup> (Finnish Environment Institute, unpubl. results). are high.**

# THE RIVER KOKEMÄENJOKI





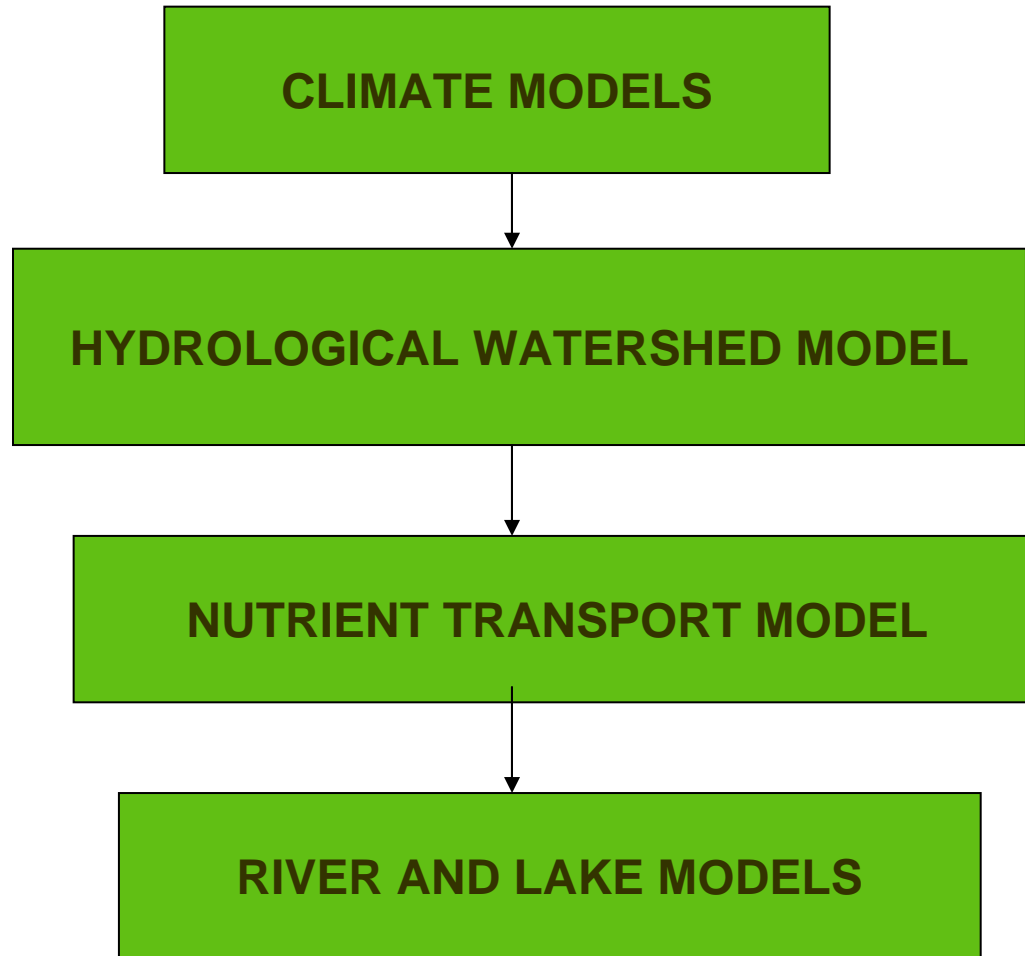
**The catchment  
of the river  
Kokemäenjoki**



**The catchment  
of the river  
Kokemäenjoki**



- 
- 
- **3. THE MODELLING SYSTEM**



## ● CLIMATE MODELS

- **The Rossby Centre coupled Regional Climate Model (RCAO) was used for the discharge simulations. The boundary conditions were taken from two global climate models: Hadley Centre (HadAM3H) and Max Planck Institut für Meteorologie (ECHAM4/OPYC3).**
- **The emission scenarios A2 and B2 from the IPCC's report were used.**

## ● CATCHMENT MODELS

- **The simulations with the hydrological watershed model of SYKE, based on the Swedish HBV model, were used.**
- **As the nutrient transport model, CATCHLOAD, developed at PREC was used.**
- **In CATCHLOAD, the catchment is divided into two parts (agricultural and forested areas) which are treated separately.**
- **CATCHLOAD has been successfully applied to several catchments in Finland and other European countries.**

- 
- 
- **LAKE AND RIVER MODELS**

- **Continuously stirred tank reactor (CSTR), plug flow reactor (PFR) or advection-dispersion reactor (ADR) hydraulics**
- **Retention processes**

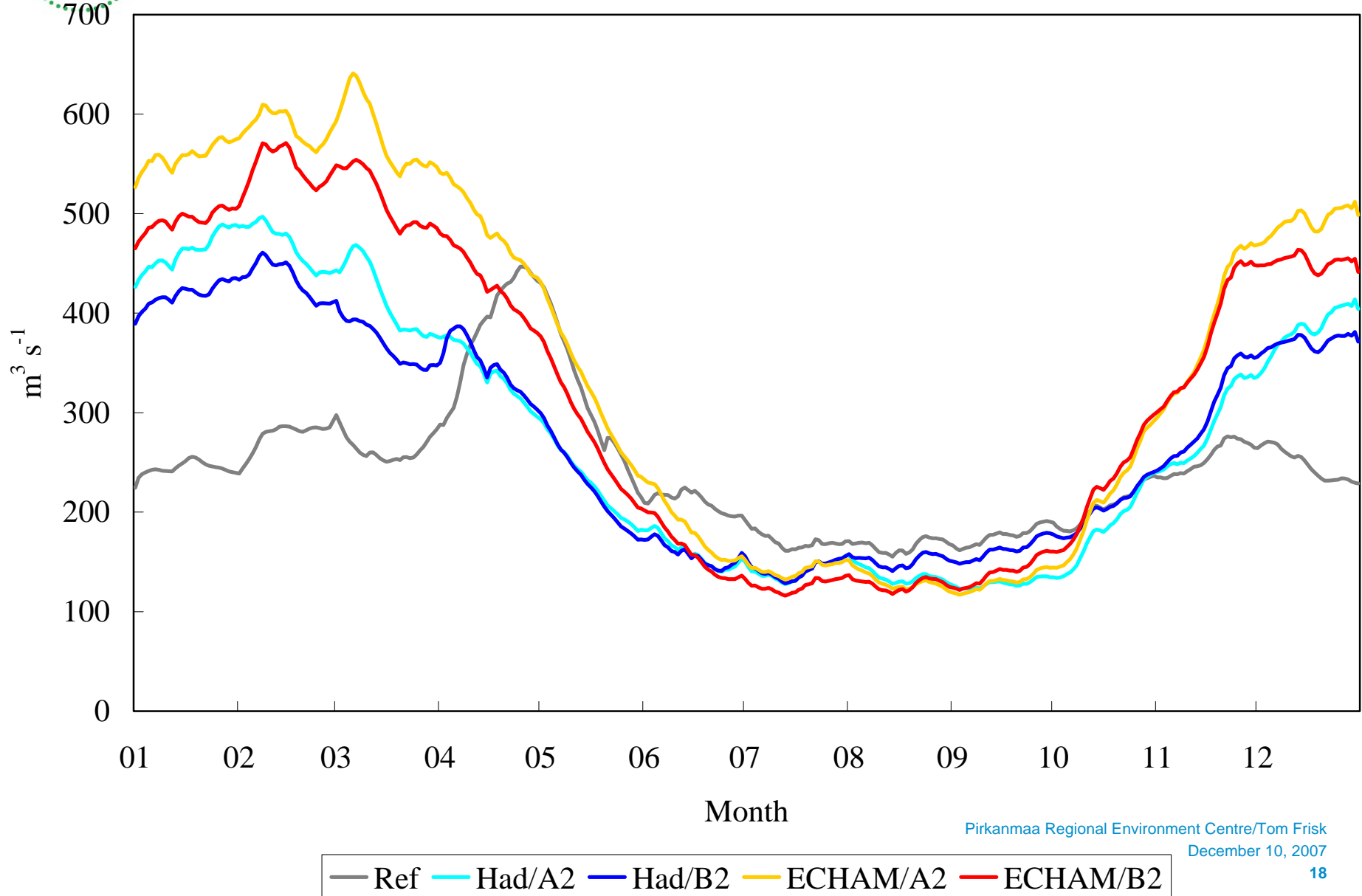
## 4. THE EXPECTED IMPACTS OF CLIMATE CHANGE

- **According to the modelling calculations, there will be a considerable change in the seasonal dynamics of nutrient loading.**
- **Annual loading will increase regardless of the climate model or the emission scenario used.**
- **Wintertime loading will be greater (up to by 100%) than today whereas the spring peak will be lower and take place earlier than in the present climate.**



# Discharge at the outlet of the river Kokemäenjoki

PIRKANMAAN  
YMPÄRISTÖKESKUS



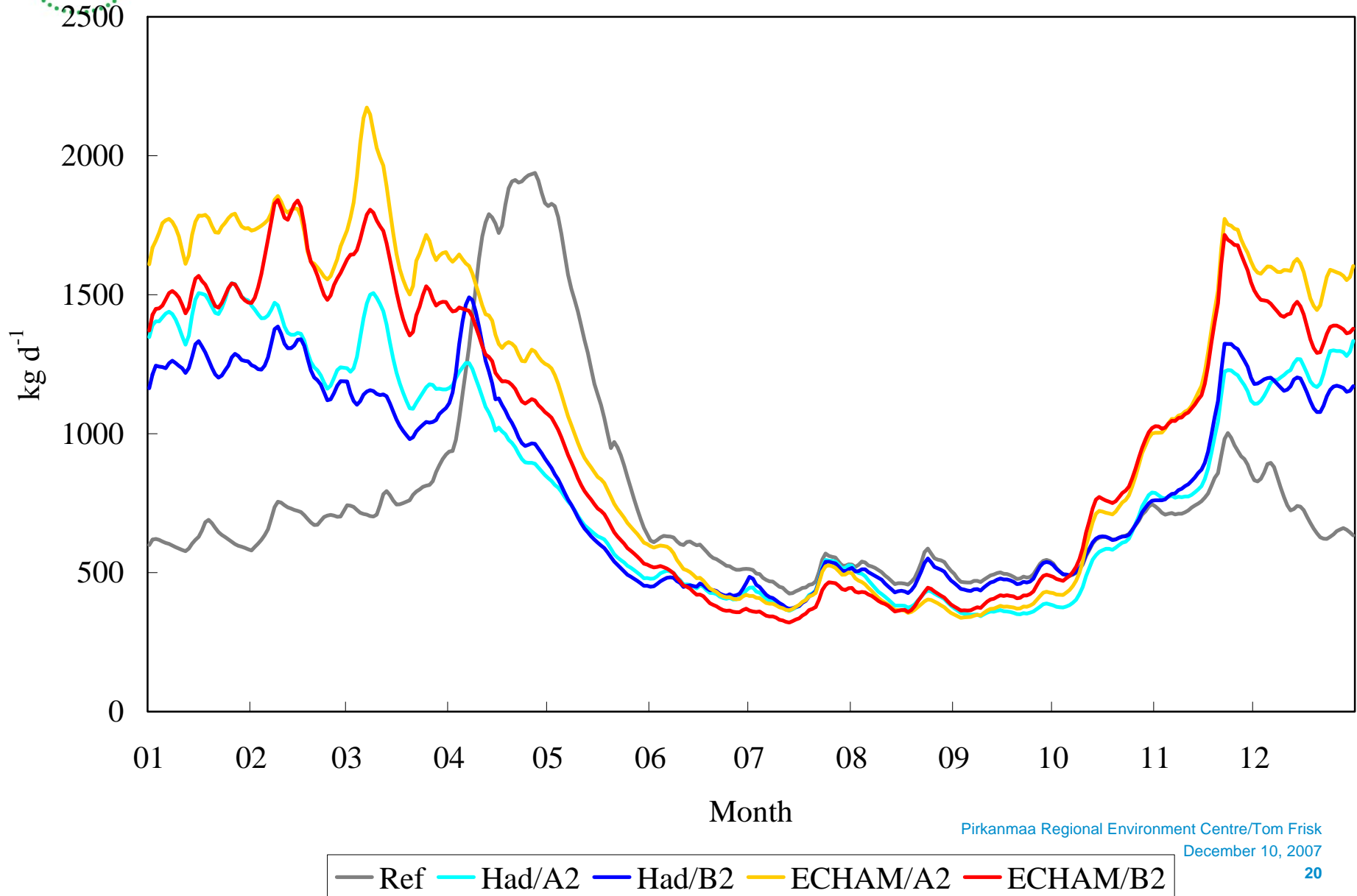
- 
- 
- Explanations

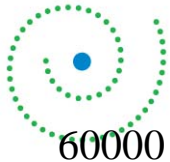
- Ref = the present situation
- Had = Hadley Centre model
- ECHAM = Max Planck Institut für Meteorologie model
- A2 = IPCC scenario A2
- B2 = IPCC scenario B2



# Total phosphorus flow at the outlet of the river Kokemäenjoki

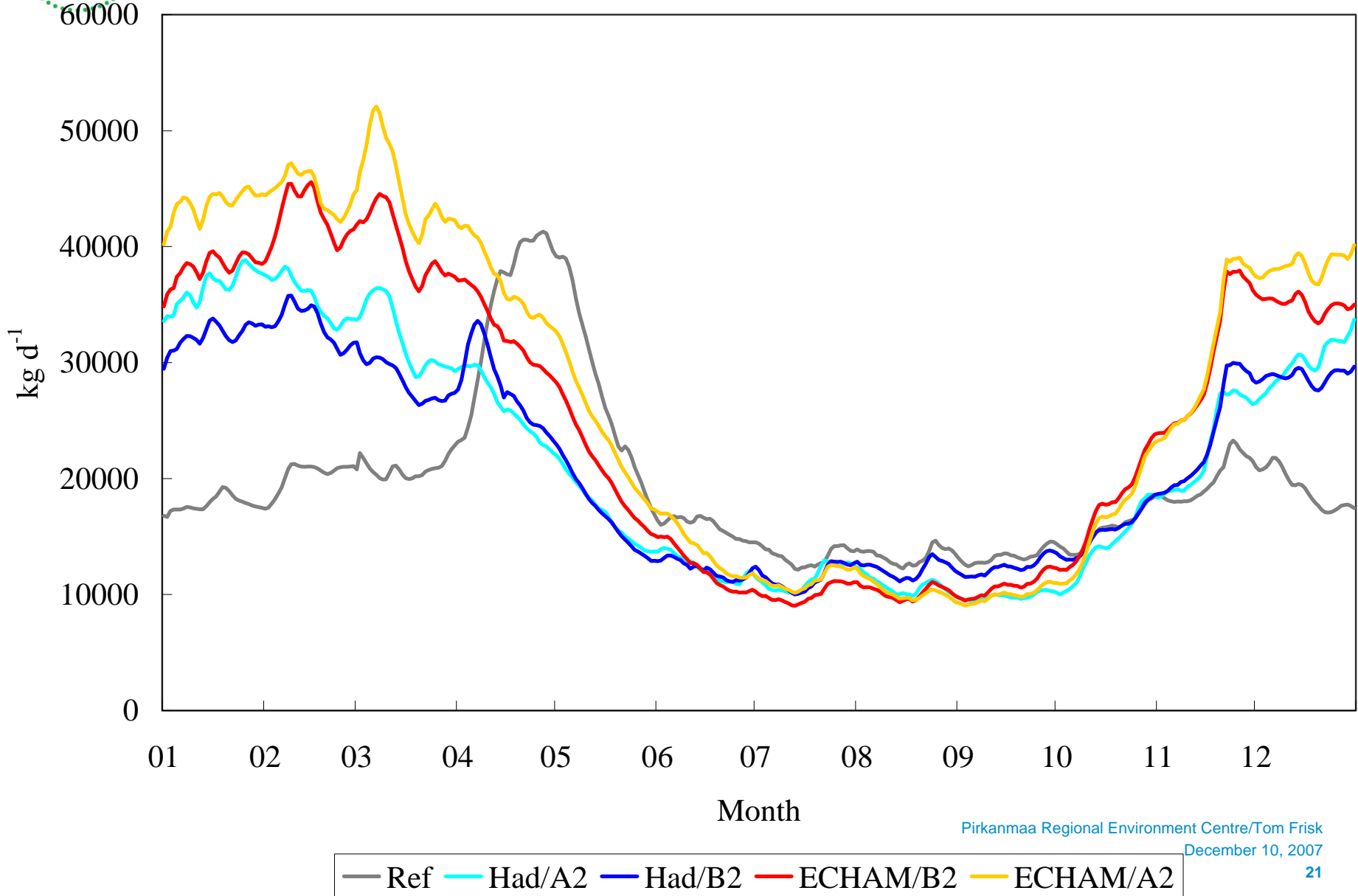
PIRKANMAAN  
YMPÄRISTÖKESKUS





# Total nitrogen flow at the outlet of the river Kokemäenjoki

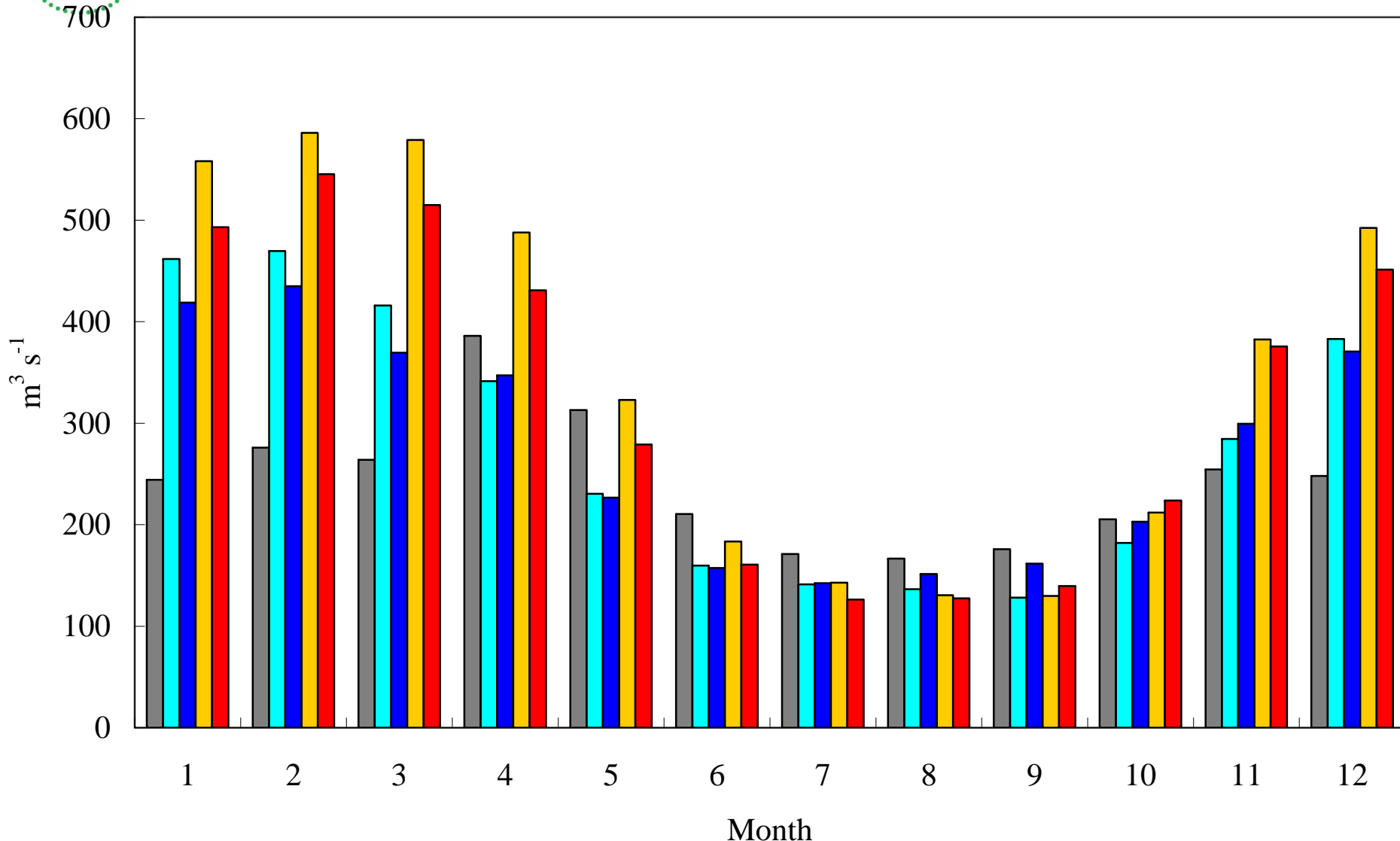
PIRKANMAAN  
YMPÄRISTÖKESKUS





# Discharge at the outlet of the river Kokemäenjoki

PIRKANMAAN  
YMPÄRISTÖKESKUS

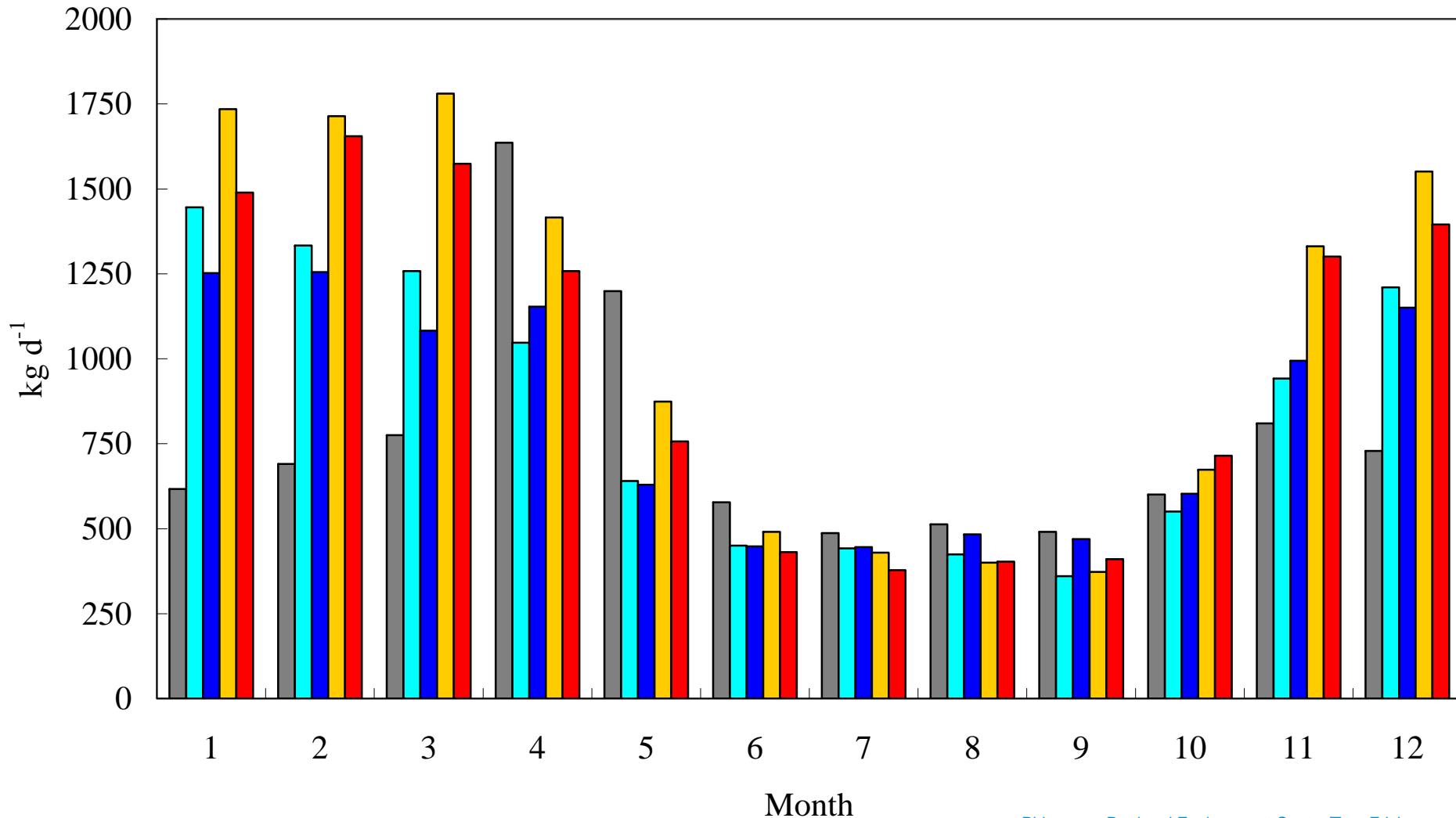


■ Ref ■ Had/A2 ■ Had/B2 ■ ECHAM/A2 ■ ECHAM/B2

# Total phosphorus flow at the outlet of the river Kokemäenjoki



PIRKANMAAN  
YMPÄRISTÖKESKUS



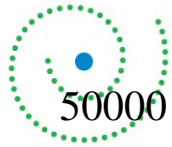
Pirkanmaa Regional Environment Centre/Tom Frisk

December 10, 2007

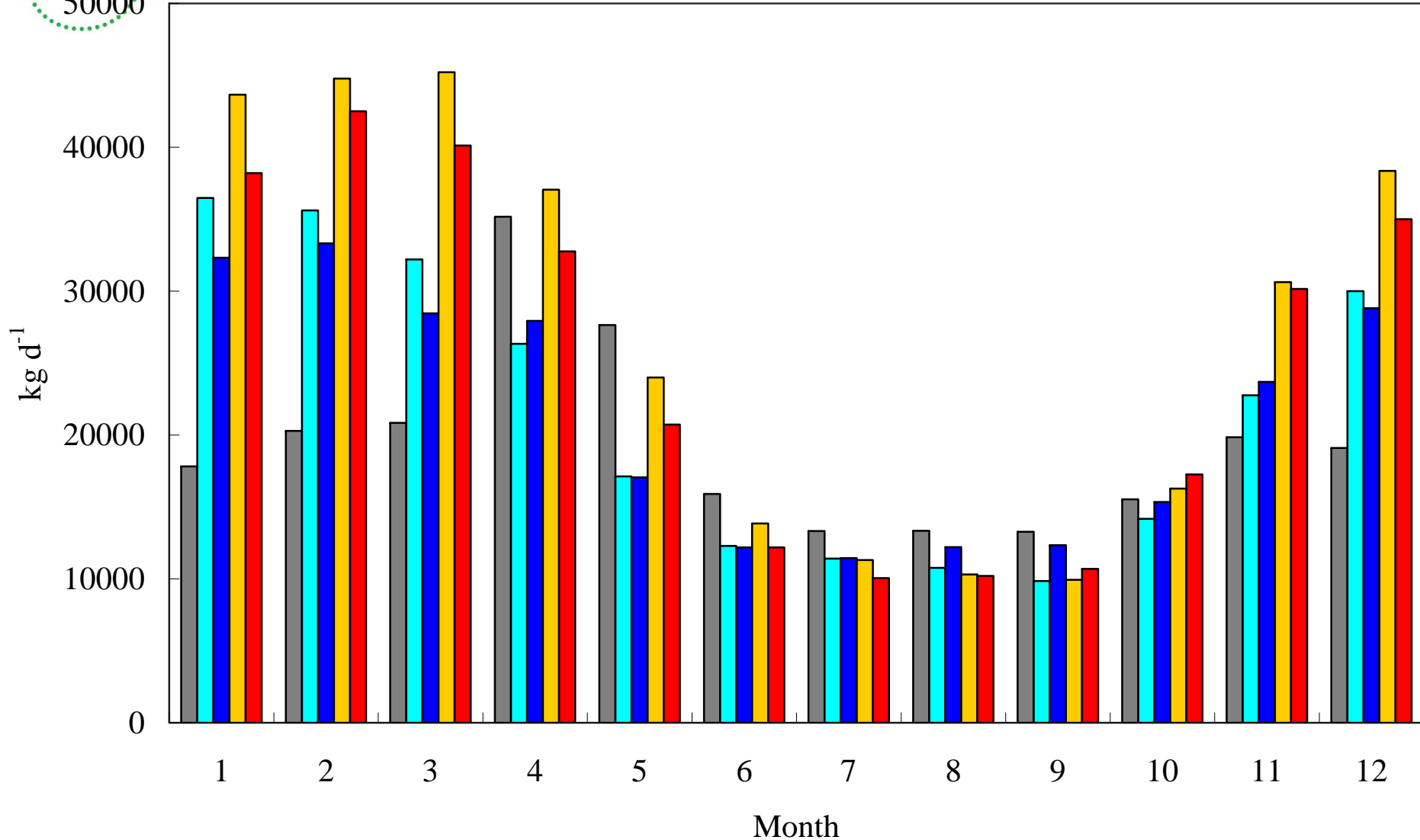
23



# Total nitrogen flow at the outlet of the river Kokemäenjoki



PIRKANMAAN  
YMPÄRISTÖKESKUS



■ Ref ■ Had/A2 ■ Had/B2 ■ ECHAM/A2 ■ ECHAM/B2

## ● ● ● **THE EXPECTED IMPACTS OF CLIMATE CHANGE (cont.)**

- **Climate change will have a clear eutrophying effect on waters.**
- **In inland waters, the effect depends on the hydraulic behaviour of the lake: in upstream lakes with short detention times the effect is not great whereas in lakes with long detention times the effect is clear.**
- **In the Baltic Sea, the eutrophying effect of the climate change is harmful.**
- **The results can be generalized to other catchments than the river Kokemäenjoki.**

## 5. FUTURE TASKS

**The results and the methods of this case study can be used in assessing:**

- **How climate change will affect human activities in general?**
- **How climate change will affect land use?**
- **How climate change will affect agricultural practises?**
- **How climate change will affect migration?**
- **How climate change will affect floods?**

- 
- 
- **FUTURE TASKS (cont.)**

- **How climate change should be taken into account in the implementation of the EU's Water Framework Directive?**
- **How climate change should be taken into account in the implementation of the EU's proposed Marine Strategy Directive?**
- **How climate change should be taken into account in the implementation of the EU's Flood Directive?**
- **How mitigation of and adaptation to climate change can be considered simultaneously?**



**THANK YOU!**

**Tom Frisk, Ämer Bilaletdin & Heikki Kaipainen**

**Pirkanmaa Regional Environment Centre  
P.O.Box 297, FI-33101 Tampere FINLAND**

**E-mail: [tom.frisk@ymparisto.fi](mailto:tom.frisk@ymparisto.fi)**